HOW TO EVALUATE BOARD PRODUCTS—p. 241

Forest Products Journal

Vol. VI, No. 7 July, 1956

FPRS National Meeting and Suppliers Exhibit Attract More Than 800 to Asheville—p. 10-A

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FOREST PRODUCTS JOURNAL

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IMPORTANT FPRS DATES

Sept. 24, 1956: Joint Meeting of Inland Empire and Pacific Northwest Sections, Lewiston, Idaho

Oct. 1956: Midwest Section Meeting, Rockford, Ill.

Oct. 1956: Upper Mississippi Valley Section Meeting, Wausau, Wisconsin

Fall 1956: Carolinas–Chesapeake Section Annual Meeting, Pinehurst, N. C.

Fall 1956: Mid-South Section Annual Meeting, Laurel, Miss.

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

March 1957: Eastern Canadian Section Annual Meeting, Montreal, Quebec

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.

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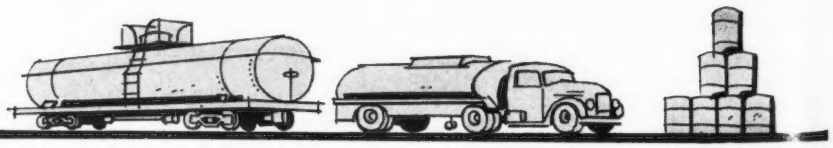

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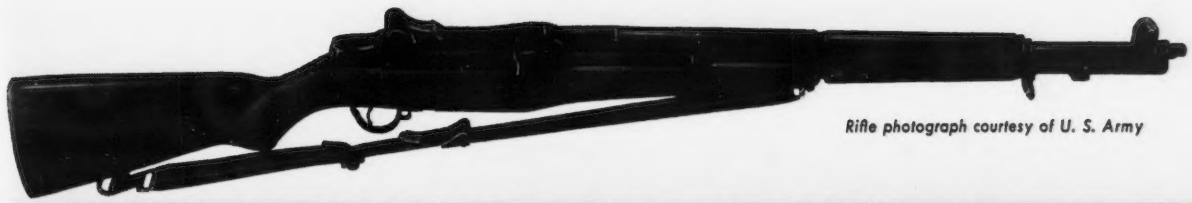
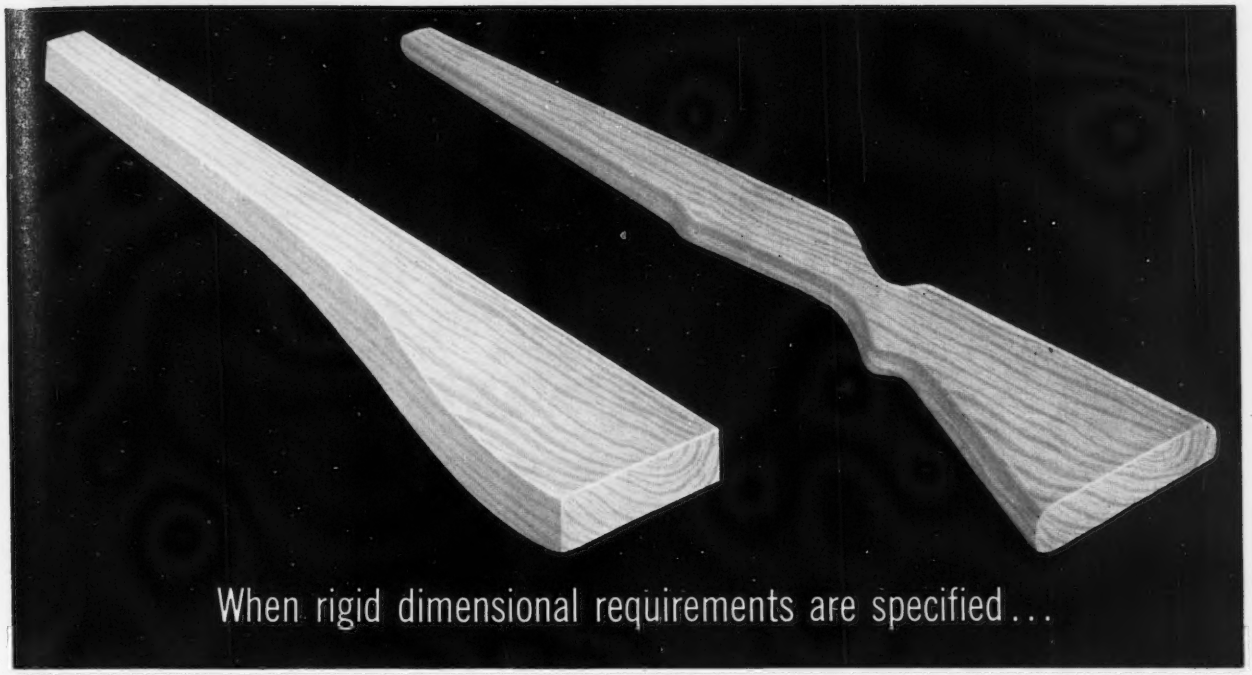


Rifle photograph courtesy of U. S. Army



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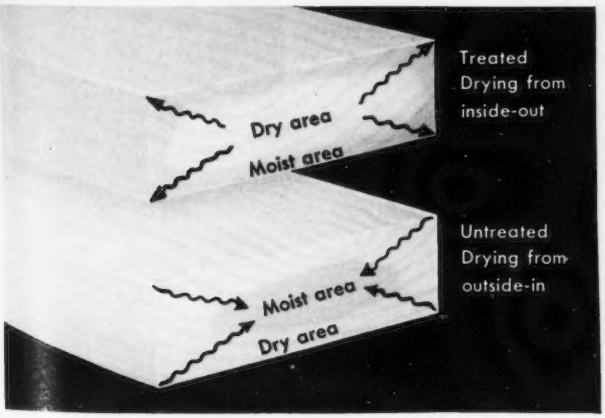

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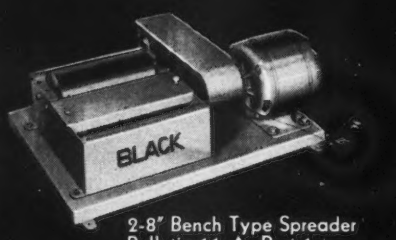
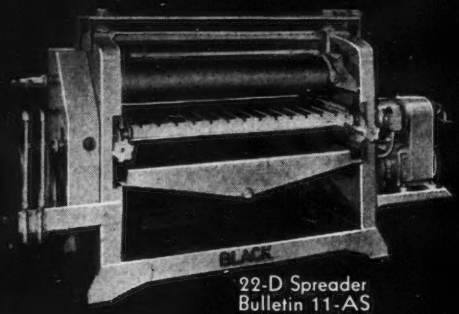


2-8" Bench Type Spreader
Bulletin 11-A, Part 1



22-D Spreader
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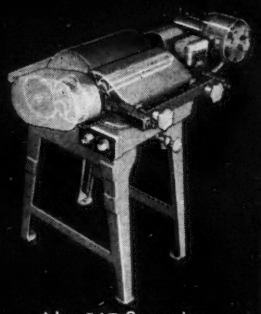

No. 567 Spreader
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Case Clamp
Bulletin 11-J

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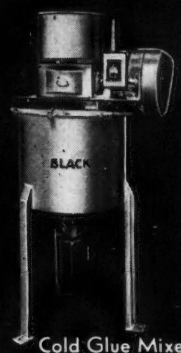

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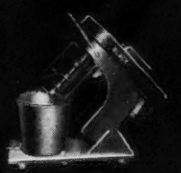

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Sash, Frame and Door Clamp
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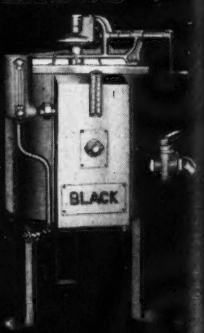

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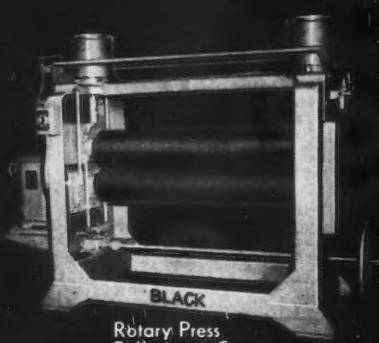

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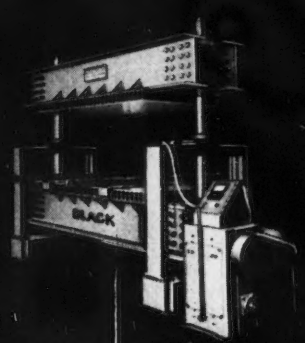

Motorized Laminating Press
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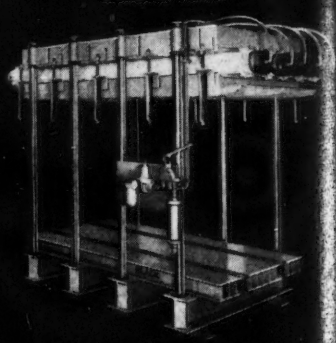

Air Hose Laminating Press
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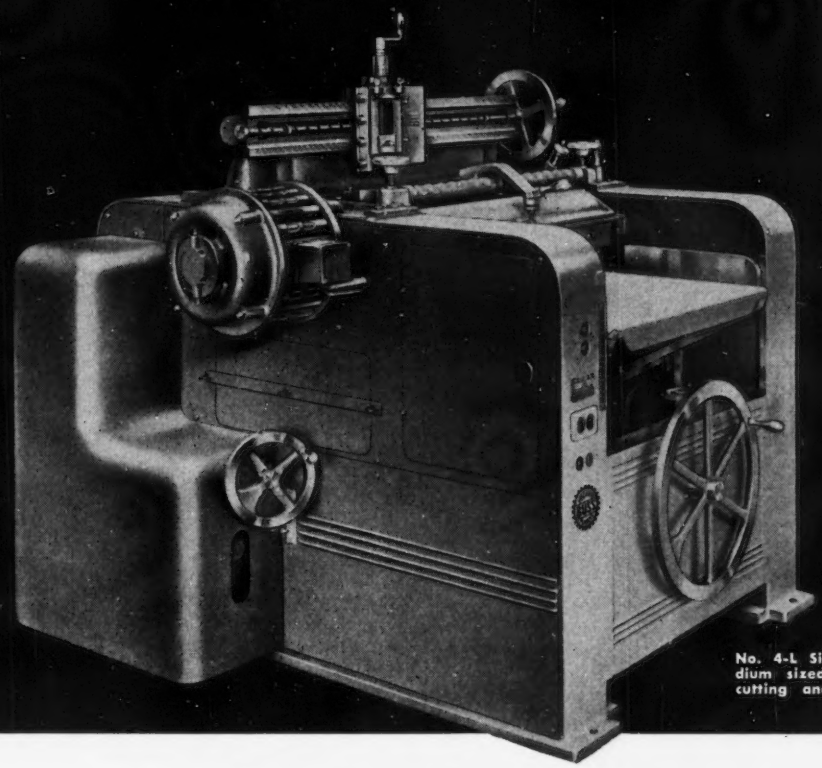
It's Much More Economical to Own MODERN BUSS CABINET PLANERS than To Do Without Them!



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Unless yours is a modern, up-to-the-minute planer, a current BUSS Cabinet Surface Planer in your shop would quickly demonstrate savings which would repay its cost many times over in a relatively short period of time. In the first place it would give you planing of finest quality at three or four times the speed of older planers . . . and that means vastly increased production plus the savings in clean-up operations that quality planing effects. Secondly, you would find that set-up and change-over time would be cut 60 to 70% by our exclusive semi-automatic controls which make absolutely accurate adjustments a matter of seconds instead of long and tedious operations of varying accuracy. Third, you would find that knife grinding and jointing is reduced to a small fraction of the time required on the older planers. And yet, these are only some of the features that make it much cheaper to own modern BUSS Planers than to do without them. Why not investigate? Write for bulletins, now!

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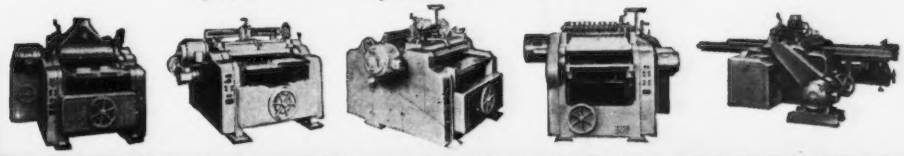

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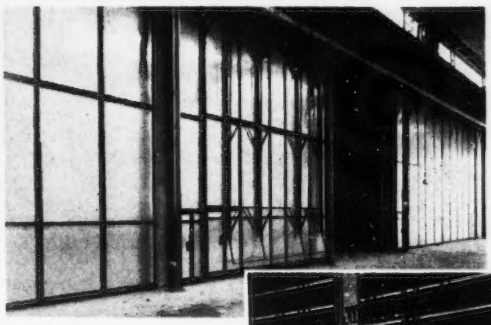
Wurlitzer compared . . .

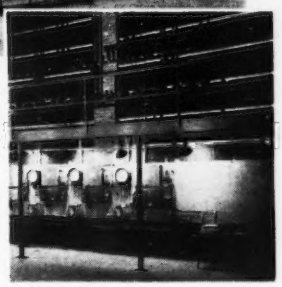
Wurlitzer Chose Standard

PACKAGE LOADED KILNS!

● Rudolph Wurlitzer Company, world's largest manufacturer of quality pianos, had a unique opportunity to compare the performance and features of various types of kilns before deciding which to install at its new plant in Corinth, Miss. Wurlitzer, like so many other leading woodworking firms, chose Standard's well-known direct-driven, internal-fan system *to assure top-quality drying!*



Here's the battery of four Standard Package Kilns at Wurlitzer's new plant in Corinth, Miss.



Operating room for the four kilns is located at the end of the kilns in the boiler room.

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Observations On Our Successful National Meeting

ASHEVILLE, N. C., JUNE 8.—As we leave this beautiful area, the scene of our 10th National Meeting, I would like, as one of my first official acts as your new president, to extend my sincere and heartfelt appreciation to the many, many persons who contributed so generously to the success of this meeting. It is difficult to conceive, unless one is intimately associated with a venture like this for well over a year, the hours of hard effort, anxiety and those spent away from the interests of one's family which such extra-curricular activity entails. I have been through a few and my sympathies are with these teams of volunteers.

R. H. BESCHER

While space does not permit naming each, I would like to pay tribute at this time to General Chairman, Dr. E. S. Harrar, "Scotty" as we all know him affectionately, to his lovely wife who gave him great moral support throughout the long preparations, and to his very capable committee.

It is interesting to note that we registered some 646 men and 150 ladies to make this our second largest national meeting registration, and by far the largest attended by ladies. Several hundred additional persons attended the exhibits only, and were not required to register for the meeting itself.

Speaking of the exhibits, the complete lower level of the Asheville Auditorium comprising over 90 exhibit areas was occupied with displays ranging from simple table-top visuals to some of the newest, full-scale woodworking machinery. As far as I could determine, there was good activity on the floor at all times.

A vote of thanks is also due the sponsors of our traditional Paul Bunyan event. This year another record was established when an estimated 700 guests attended the delightful barbecue supper at Heintooga picnic area some 6,000 ft. up in the Smokies.

Still another fact I observed was the considerable number of younger technologists, engineers, chemists, and similar technical men in attendance. Many represented the sole technical departments of lumber or wood products companies and are indicative of the marked trend in our industry toward attracting and utilizing more technical personnel. Similarly, it is heartening to note that increasing numbers of such men are making use of Forest Products Research Society services and facilities.

Finally, if I might digress from these observations to a bit of my own philosophy, this National Meeting was proof once more that our wood industry can be just as big, important and progressive as we as individuals want to make it. Each of us, in whatever line of endeavor we are engaged, creates his own world . . . as large or as small . . . as important or as insignificant, according to his knowledge, ambitions, energies and associations. Each can enlarge his world by application, study, and wider association. There is, I believe, no better place in our industry to establish firm technical friendships than in our growing Society.

RALPH H. BESCHER, *President*

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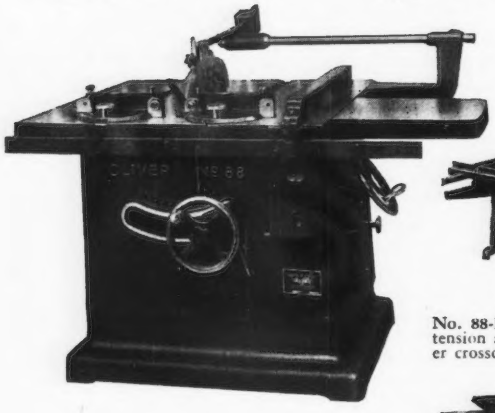
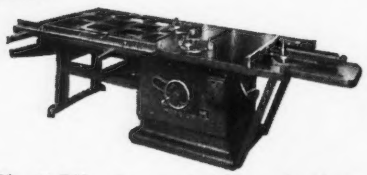
Are you losing money sawing stock of large size?

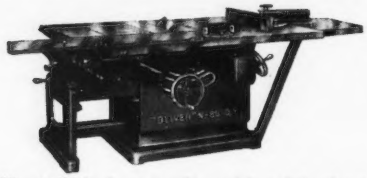
"OLIVER" SAW BENCHES simplify the handling of large panels



6 models of extra large capacity



No. 88-DX — Large main table, and table extension at right of saw. No. 88-DXL has greater crosscut capacity and larger rolling table.



No. 88-DY—Special rolling table at left of saw and table extension at right. No. 88-DZ doesn't have table extension at right of saw.

Choose the machine that fits your needs best!

● If your operations require the handling of stock of large dimensions, look into the advantages of the No. 88 Tilting Saw with its 7 different tables.

● This "Oliver" is built with power, stamina, capacity and speed to cut your production costs. It rips, crosscuts, dadoes and miters with precision. Has most complete and accurate set of gauges to reduce set-up time. The No. 88-D (above) rips to 50", crosscuts 48" x 1" thick. Write today for Bulletin No. 88.

No. 88-DW — Non-tilting arbor and table extension at right of saw. Rolling table at left of saw. No. 88-DWL has greater crosscut capacity and larger rolling table.

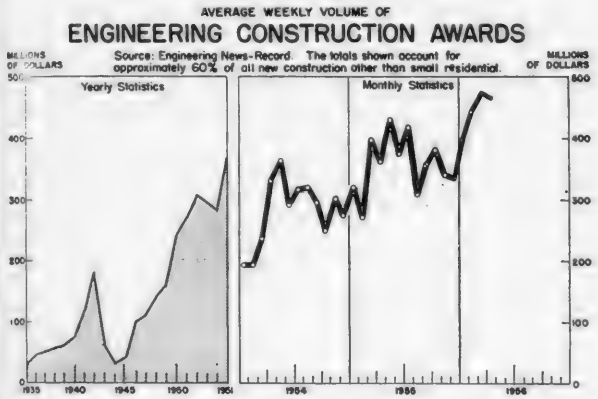
No. 838 — Heavy duty machine with traveling saw. Capacity: 12' long, 6' wide, 4" thick.

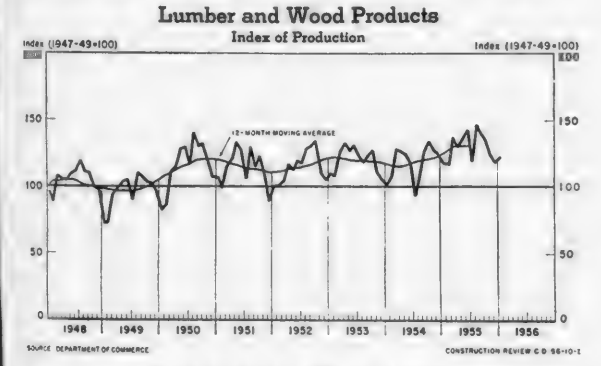
OLIVER MACHINERY CO.
GRAND RAPIDS 2, MICHIGAN

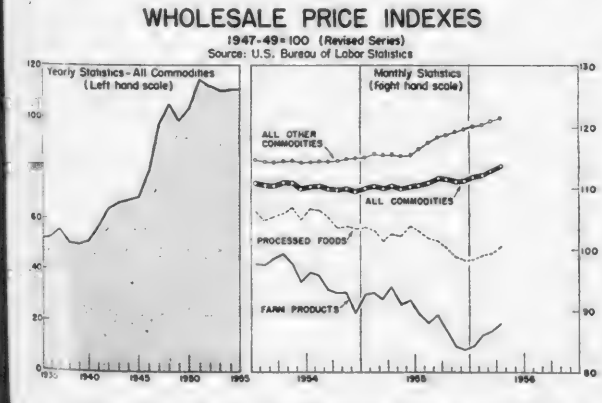
FPRS NEWS-DIGEST

Volume VI JULY, 1956 Number 7

GRAPHIC TRENDS







DOUGLAS-FIR PLYWOOD production is shading last year's figures. Through first 19 weeks of '56, output maintained 8.6% lead over same period last year.

—Veneer Newsletter

BUSINESS OUTLOOK

LARGE INCREASES in value of products shipped were reported by millwork, plywood, and prefabricated wood products industries in 1954 Census of Manufactures. Advance reports recently issued by Bureau of Census show millwork shipped in '54 had value of $873 million, up 60% from '47; plywood increased 89% to $514 million; prefabricated products were up 117% to $224 million.

PRACTICAL RESEARCH projects suggested for study by forestry schools, laboratories, and other research agencies are contained in list of 111 potential studies compiled by Northeastern Wood Utilization Council, Box 1577, New Haven, Conn. Special bulletin describing projects is available from Council at 25¢ each. Compilation was undertaken to stimulate researchers to explore "grass-roots" problems.

SAFETY—INTENSIVE STUDY of work accidents in high-hazard logging and sawmill operations will be conducted by U. S. Labor Dept. Bureau of Labor Statistics. Purpose is to provide detailed data on occurrence and causes of accidents, for use in accident prevention. Survey results will be made available through industry's trade associations.

NO LIMIT ON TOMORROW for American industry is seen by T. B. McCabe, president of Scott Paper Co. Addressing bankers convention, he expressed confidence that "technology will never cease to accelerate and expand", said his firm had already raised 1953 goal of doubled sales in five years.

—Forestry Digest

National Meeting Focuses on Residue Utilization

Composition Board Exerting Effect Throughout Industry

There is a "gold mine" to be found in wood residues and improved production practises if the 50,000 or more companies that make up the diverse forest products industry—from logging to furniture manufacture—will take advantage of them. That was the tenor at FPRS' Tenth National Meeting June 4–8 in Asheville, N. C.

More than 1,000 members, exhibitors, and guests from the U. S., Canada, and six other countries attended. Official registration was 808.

The meeting demonstrated once again the permanent need and eager acceptance of a technical and non-technical organization which can provide meeting grounds for the dissemination and interchange of information on every phase of wood technology.

Our forests have become an increasingly valuable resource in the last 15 years, according to Clark C. Heritage, Consultant, Tacoma, Wash. As a result, three major things have happened: (1) forestry has been put on a sustained-yield basis to provide ample resources for the future; (2) the industry is striving to utilize as much of every tree as possible; and (3) wood industry research has increased ten-fold since World War II. "Integration between pulp and lumber have made it possible to use between 75–80 percent of the tree. If you make particle board with other residuals you push the percentage even higher," Heritage said.

What are the coming things in the wood industry? New products from bark, a gradual increase in the use of sawdust, and the expanding and perfecting of existing products, he said. Other developments will include chemical plants using wood as a raw material and the day when all lumber will be delivered to customers cut to specifications.

Full-Use Is Goal

Particle board is the hottest thing to hit the wood industry in recent years, according to Dr. George Marra, Head of the Division of Industrial Research, Washington State College, and Chairman of FPRS' National Composition Board Committee. Particle boards are tough, cheap to produce, can be built to order, made fire-, termite- and moisture-resistant, and can even be turned out in colors. Their development has opened the way for the industry to be able to utilize 100 per cent of a tree. These

(Continued on page 12–A)

EXECUTIVE BOARD MEMBERS meeting in Asheville were, seated: R. H. Berry, Southwest Region; President-Elect F. H. Kaufert; President R. H. Bescher; Past President Moss B. Christian; standing: W. R. Warner, South-Central; W. L. Irwin, Southeast; J. D. Ritchie, Northwest; C. R. Lockard, Northeast; R. L. Hiller, North-Central. Vice-President W. J. Eason was unable to attend.

Ralph H. Bescher Becomes Tenth President of Society

Ralph H. Bescher, Pittsburgh, Pa., was installed as FPRS President during the annual business meeting at the Tenth National Meeting. He succeeds Moss B. Christian, Tallulah, La., who will remain on the Executive Board as Past President.

W. J. EASON

President-Elect for the coming year is Dr. Frank H. Kaufert, Director, School of Forestry, University of Minnesota. Elected to the Vice-Presidency was W. Jeter Eason, Vice-President, Nickey Brothers, Inc., Memphis, Tenn.

W. L. Irwin, Southeast Region, and W. R. Warner, South-Central Region, were elected to three year terms on the Executive Board. Irwin is Works Manager, Poinsett Lumber and Manufacturing Co., Pickens, S. C., and Warner is Manager, Southern Lumber Co., Warren, Ark.

Retiring from the Executive Board are L. J. Carr, Past President; E. S. Harrar, Southeast Region; and Frank T. Parrish, Northeast Region.

Lockard Named Northeast Regional Board Member

Charles R. Lockard, Upper Darby, Pa., has been named Northeast Regional Member of the FPRS Executive Board, to serve one year of the unexpired term of Frank T. Parrish, who resigned. Lockard will also serve as General Chairman of the 11th National Meeting, to be held June 24–28, 1957, in Buffalo, N. Y. The new board member is Chief, Forest Utilization Service, Northeastern Forest Experiment Station.

Parrish, who completed two years' service on the Board, also served as National Membership Chairman and is a past Chairman of the Northeast Section.

On The Cover

National Meeting activities are discussed by, top left: P. H. Lane, Wausau, Wis.; R. K. Peter, Athens, Ga.; and D. E. Herrick, Carbondale, Ill. Top right: registrants view model of particle board plant at Suppliers Exhibit. Lower left: part of crowd of 700 boarding buses for Paul Bunyan Barbecue and Smoky Mountains tour. Lower right: attending meeting of Subject Matter Committee Chairmen were, left to right: H. O. Fleischer, C. S. Latimer, L. A. Patronsky, I. E. Dickinson, A. J. Panshin. Top two and lower left photos courtesy of Asheville Citizen–Times.

Tenth National Meeting Registration List Available

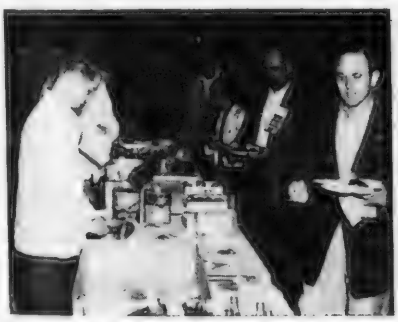
A complete list of the more than 800 persons officially registered for the National Meeting is available to FPRS members on request. Single copies may be obtained from the Executive Secretary, Box 2010, University Station, Madison 5, Wis.

More Than 800 Participate in National Meeting Activities

REGISTRATIONS for optional plant tours were signed up by L. Gaby and B. M. Witherow, left. At right are C. E. Lehman, High Point, N. C., and R. C. Gill, Gowanda, N. Y.

HOST HOUR (left) on Sunday, June 3, kicked off full week of technical sessions and outstanding program of entertainment. Right: T. R. Truax, U. S. Forest Products Lab, is presented gift from Society by President-Elect F. H. Kaufert for "service to industry."

SECTION OFFICERS ADVISORY COMMITTEE met with National Executive Board to coordinate matters of mutual interest.



CHOW LINE of more than 700 persons at Paul Bunyan Barbecue at Heintooga Overlook in the Smoky Mountains.

PAUL BUNYAN BARBECUE sponsors' representatives joined other FPRS members and guests for afternoon of sightseeing, climaxed by barbecue supper.

LEADING MEMBERSHIP SALESMAN was J. B. Huffman, right, being congratulated by R. L. Hiller, National Membership Chairman, and President R. H. Bescher. Hiller, on behalf of American Cyanamid Co., presented Huffman with set of dishes.

WOOD AWARD winners were, left, S. P. Fox, first place; right, N. C. Higgins, second. Seated center is J. F. Koellisch, Editor and Manager of Wood and Wood Products magazine; standing: H. O. Fleischer, Chairman of Judges; A. J. Panshin, Chairman of Industry-Education Committee.

PLANT TOURS were made to ten industries in Western North and South Carolina. Left, registrants view combination bolter-trim saw for making dogwood shuttle blocks at Draper Corp., Swannanoa, N. C. Right, inspecting hardwood flooring and paneling in new offices of Williams–Brownell, Inc., Asheville hardwood dimension plant.

Wood Research Has Unlimited Potential, Robertson Asserts

R. B. ROBERTSON

The possibilities of research in the wood industry are limitless, according to Reuben B. Robertson, Sr., President and Chairman of the Board of Champion Paper and Fibre Co. He was principal speaker at the National Meeting Official Luncheon, attended by more than 500 persons.

As in the past, when decreasing supplies of lumber resources and growing demand for wood gave impetus to forest conservation, so too are economic pressures now stimulating interest in the utilization of all wood by-products, he pointed out. While painting a bright picture of the future, Mr. Robertson warned, "We are still confronted with a very large area of ignorance when it comes to practical ways of combatting diseases of the forest."

The speaker cited several woods which may have double-use possibilities and warrant study. He also urged research to find partial substitutes for pine fiber through such annual crops as bamboo, esparto, cotton, corn stalks, and the like.

Christian Honored

Retiring FPRS President Moss B. Christian was presented a deer rifle with telescopic sight in appreciation for his services to the Society. President R. H. Bescher, in making the presentation, cited Mr. Christian's service to the Society in various capacities since 1949.

Citation to Truax

President-Elect Frank H. Kaufert presented a gift on behalf of the Society to Dr. Thomas R. Truax, Chief, Division of Timber Processing, U. S. Forest Products Laboratory, for his "years of service to the forest products industries through individual research and leadership of research, contributions to the development of woodworking adhesives and the science of gluing, and cooperation with industries in solving many glued wood construction problems."

Wood Awards Presented

The annual "Wood Awards" were presented by J. F. Koellisch, Editor and Manager of WOOD AND WOOD PRODUCTS. First place certificate and $350 was awarded to Selwyn Fox, U. of Toronto, for his paper on "An Investigation into the Effects of Certain Variables in Scarf-Jointed Timber Laminations." Norman C. Higgins received second prize for his paper based on studies at Penn State University on "The Effect of Species on the Relative Humidity-Equilibrium Moisture Content Relationship."

Residue Utilization

(Continued from page 10–A)

boards can be used for cores for furniture, wallboard, paneling, shelving, and other products.

Composition board may mean cheaper homes for Americans, said Willard J. Worth, Director of Research, National Homes Corp., Lafayette, Ind. He said that composition board today has an annual potential in home consumption of 6 billion sq. ft., used chiefly in wall sheathing, interior paneling, and exterior siding. We have reached the point where today we can cover the entire basic framing of a house with various types of composition board.

In line with the growing importance of wood particle board manufacture, a new concept of chipping wood was described by J. Weber Marshall, representing the Guilliet Co. of France. This company has recognized the tremendous diversification of particle boards and chips for pulp and has developed a machine which is adaptable to producing any size or thickness of chip desired for a specific quality of board or pulp. The machine is said to process any raw material now used in the wood industries without limitation as to size and shape and can handle raw material from 1–14 inches in diameter, square or round in shape.

Integration Expanding

The principle of integration between the pulp and lumber industries, envisioned and introduced by such companies as Weyerhaeuser Timber Co. and Crossett Co. a decade ago, has expanded to the point where today almost all of the large pulp mills in the West are depending upon lumber industry residues for a large percentage of the pulp raw material requirements.

Continuing its program of integration, N. T. Shelton, Indus. Eng., The Diamond Match Co., Chico, Calif., stated that his company is erecting a new forest products plant which will include a sawmill having an annual capacity of 85 million bd. ft. together with complete lumber manufacturing facilities, and a pulp plant to produce its established lines of molded pulp products. The wood residuals developed by the sawmill will become the raw material for the pulp mill. It was found that, taking an average 30-inch diameter log, the following amounts of usable material can be developed: green chippable residue—22%, green sawdust—14%, dry shavings and sawdust—10%, dry trim—1.6%, and dry lumber 48%.

Reavis C. Sproull, Manager, Technical Services, Philip Morris, Inc., Richmond, Va., formerly Director of the Herty Foundation, Savannah, Ga., explored the vast possibilities of whole tree harvesting—a new concept in forest management as related to utilization. It means collecting all the tree which can be salvaged, including trunks, roots, limbs, and even twigs. In the past, it has been estimated that less than 50 per cent of a tree felled in the forest finds its way to market. Today, we have tractors which can uproot a tree in 30 seconds and machines which can debark and otherwise process raw materials in preparation for further utilization. Such raw materials will go into lumber, paper fibers, particle boards, and the growing chemical industry. Whole tree utilization could increase our pulp yield from $2.7 to $3.6 billion annually and raw materials from 30 to 40 per cent.

Reduced Waste 90 Per Cent

Practicing what FPRS preaches has enabled a progressive sawmill to cut its waste 90 per cent in recent years. E. P. Ivory, President of the Ivory Pine Co., Dinuba, Calif., said that before conservation practices were put into effect, his sawmill was burning 292 tons of waste per day in the form of bark, sawdust, slabs, and shavings. Then his mill took the following steps to cut waste: (1) started making lath strips for use in fruit railroad cars; (2) began shipping 45 tons of chipped wood per day to a paper mill; (3) moved green sawdust to poultry and dairy farmers; (4) graded sawdust and chips for such uses as butcher shop floor covering, sweeping compound, fiber for roofing; and (5) prepared ground bark for use as compost. As a result, the mill cut its waste from 292 tons a day to 30–35 tons.

A lawyer, Noel S. Symons, Buffalo, N. Y., urged lumbermen to cut down noise in their mills, a step which would increase production, decrease absenteeism and accidents, and improve plant morale. Symons said he was confident that the future would see the designing and manufacturing of less noisy machines and the quieting of existing machines.

A new machine, described for the first time before FPRS delegates, is a "knife" which slices lumber without sawdust waste. If developed into widespread usage, it will save the lumber industry enormous sums; for in cut-

(Continued on page 14–A)

Typical Booths at FPRS Suppliers Exhibit in Asheville

National Adhesives

New York College of Forestry

Weyerhaeuser Sales Co.

American Cyanamid Co.

Dependable Machine Co.

Mattison Machine Works—Greenlee Bros. & Co.

Timber Engineering Co.

MOORE DRY KILN COMPANY
MOORE CROSS-CIRCULATION LUMBER AND VENEER DRYERS
LUMBER STACKERS, UNSTACKERS AND POWER TRANSFER CARS
TO REDUCE COSTS-INCREASE PRODUCTION
MOORE

Moore Dry Kiln Co.

The Dean Company

Residue Utilization

(Continued from page 12–A)

ting small items from a large piece of wood by sawing, up to 50 per cent of the material may now be wasted in sawdust. The knife, developed by Gilbert Schneider of Lexington, Ohio, slits without producing any sawdust.

These examples of forest products progress were typical of information contained in more than 60 papers presented at technical sessions covering wood preservation, gluing, seasoning, chemistry of wood, machining, logging, sawmilling, composition boards, plywood, furniture production, packaging and finishing at the week-long meeting.

Other Features

In addition to the technical meeting, a "Forest Products Suppliers' Exhibit", representing more than 70 organizations, was held throughout the four-day meeting and attracted upwards of 800 persons.

The social highlight of the meeting was the Paul Bunyan Barbecue and tour of the Great Smoky Mountains, sponsored by forest products industry suppliers. Nearly 700 persons, reportedly the largest group ever to make such an excursion from Asheville, boarded buses the afternoon of June 6 for the 130-mile trip through one of the most scenic areas in the East. First stop was Ocunaluftee Indian Village, replica of a 200-year-old village with its stockade, sweat-house, and examples of early crafts. Another visit was made to the Pioneer Exhibit at Ocunaluftee Ranger Station, a group of authentic log buildings containing the implements and utensils of the pioneer mountaineer era of the Southern Appalachians.

Climaxing the trip was the southern style barbecue, complete with mountain music, at Heintooga Bald Overlook. On the return trip to Asheville, the buses stopped at Mile High Overlook, regarded as the most spectacular view of the Great Smokies.

Concluding the full-week program on June 8 were plant tours of ten outstanding industries in western North and South Carolina. Registrants had their choice of full-day trips to Broyhill Furniture Factories, Lenoir, N. C.; Drexel Furniture Co., Drexel, N. C.; Taylor-Colquitt Co., Spartanburg, S. C.; Poinsett Lumber and Manufacturing Co., Pickens, S. C.; and half-day trips to Williams-Brownell, Inc., Asheville; Draper Corp., Swannanoa, N. C.; Champion Paper and Fibre Co., Canton, N. C.; Morgan Manufacturing Co., Black Mountain, N. C.; Ecusta Paper Corp., Pisgah Forest, N. C.; and American Enka Corp., Enka, N. C.

Committee Teamwork Responsible For National Meeting Success

Credit for the success of FPRS Tenth National Meeting is due in large measure to the volunteer committee members who spent many hours in preparation for and during the meeting to assure a smooth-running event.

General Chairman E. S. Harrar was responsible for co-ordinating the work of the entire committee, which demonstrated splendid teamwork throughout the week. Walton R. Smith, Asheville Arrangements Chairman, did an outstanding job in overseeing details on the scene, and was assisted by several staff members of the Southeastern Forest Experiment Station.

James S. Bethel was in charge of arrangements for the highly successful "Suppliers Exhibit". Assisting his committee during the week were six students from N. C. State College. Jack Hayward was Chairman of the Paul Bunyan Barbecue, social highlight of the meeting.

Local publicity, under the chairmanship of Harvey Loughead, was the most complete in FPRS history. In addition to daily newspaper coverage, four television programs were arranged and viewed by a six-state audience. Details of finance and budget were ably handled by G. M. Hill.

Other committee members contributing to the meeting were: finance, C. M. Carey, Jr.; publicity, R. C. Buchholz and W. J. Damtoft; Paul Bunyan Barbecue, J. Colucci, Jr., R. C. Garrison, and R. G. Lenox; exhibits, H. A. Lockemer, R. E. Palmer, and P. F. DeSaix; meeting rooms, signs, and supplies, A. S. Todd, Jr.; transportation and field trips, B. M. Witherow; housing, M. A. Taras; registration and tickets, J. B. Veach, Jr. and A. C. Barefoot; entertainment and meals, W. L. Irwin and R. A. Wood; hospitality, J. B. Veach, Sr.; door prizes, R. M. Carter and E. S. Johnson; and ladies program, Mrs. W. R. Smith.

Jasper Manufacturers Hosts To Ohio Valley Section

The Jasper Manufacturers Association, as hosts, literally "rolled out the carpet" for the Spring meeting of the Ohio Valley Section May 17–18 at Jasper, Ind. The meeting, one of the most successful in the young Section's history, explored new approaches to wood utilization. Social events included a fine luncheon and a "Chips and Sawdust Hour".

Papers were concerned with such subjects as Fundamentals of Finishing, Jasper Lacquer Co.; Chip Particle Board, Chipcraft, Inc.; Care and Grinding of Knives and Cutters, G. M. Diehl Co.; Salt Lumber Cure, Federal Prison Industries; and Trends in Furniture Design, Design Council. Harold Mitchell, Chief, Division of Timber Growth and Utilization Relations, U. S. Forest Products Lab, gave the luncheon address emphasizing the effect of heredity and environmental factors on the future quality of Ohio Valley hardwood stands.

Pacific Northwest Section Discusses Upgrading, Automation

Upgrading lumber products, automation, automatic sorters, and the proper saw for the job were discussed May 7–8 at the FPRS Pacific Northwest Section Meeting in Eugene, Oregon. Field trips were made to the Weyerhaeuser Timber Company's Springfield operation where a 72-inch Hansel barker was viewed along with log sorting arrangements, sawmill, and pulp mill, and Booth Kelly Lumber Company's new Nicholson barker installation, sawmill, and remanufacturing unit.

P. S. Quelch gave comparisons between proper feed rates, saw gauges, tooth spacing and horse power. S. M. Batori outlined the need for automation in sawmilling and cited examples of riderless carriages, pre-setting, and others. The Temple-Bovay Automatic Lumber Sorter which is set up to make 51 separations using two sorters in tandem and which reduces manpower requirements from 38 to 8 men was described by W. N. Pauley. Willard Morss discussed the work of the Weyerhaeuser Timber Co. in upgrading lumber by sealing or plugging knots.

Robert M. Samuels stated that pulp production may increase 65 per cent by 1975 and urged research to further utilization of residues. Robert Quick described a new pulp operation at the Longview, Wash. plant of Weyerhaeuser Timber Co. which is based on the use of red alder logs of 8 to 20 inches in diameter. Harold MacLean pointed out that in Western red cedar heartwood, the darker the color of the wood, the lower its extractive content and durability.

Great Lakes Section Elects New Officers

Gardner G. Garlick, Vice-President of Protection Products Manufacturing Co., Kalamazoo, Mich., has been elected Chairman of the FPRS Great Lakes Section. Other new officers are: First Vice-Chairman, Fred Atkinson, National Casein; Second Vice-Chairman, Samuel W. Tamminga, Vice-President of Hekman Furniture Co.; Secretary, E. Brooks Applegate, Travis-Applegate Co.; and Treasurer, Norman C. Franz, U. of Michigan.

Three Section Meetings Cover Subjects of Area Interest

NORTHERN CALIFORNIA SECTION meeting April 27 was addressed by Dean Henry J. Vaux, California School of Forestry. Seated are: R. H. Berry, Southwest Regional Member of Executive Board; F. E. Dickinson, Section Trustee; A. B. Anderson, Trustee; H. N. Stephenson, Chairman. At right are: N. T. Shelton, Vice-Chairman, and R. M. Kuhn, Secretary-Treasurer.

Speakers at Northern California meeting in San Francisco were, left to right: O. J. Bugge, R. D. Roseberry, Albert Nobell, Past Chairman E. P. Ivory, J. J. DeFino.

OHIO VALLEY SECTION meeting was addressed by Jack Thornbury, Jasper Lacquer Co., second from left. At right are R. L. Hiller, North-Central Regional Member of Executive Board, Section Chairman Carl Seng.

Harold L. Mitchell, U. S. Forest Products Lab, was principal luncheon speaker at Ohio Valley meeting May 17–18 in Jasper, Ind. Part of group attending luncheon is shown at right.

Ohio Valley Section officers met with Executive Secretary F. J. Rovsek. Left to right are: S. Durst, Trustee; Rovsek; J. H. Wilson, Trustee; Carl Seng, Chairman; R. H. Elliott, Vice-Chairman; P. J. Fenn, Treasurer.

Speakers at Jasper meeting included Ralph Shepard, Federal Prison Industries, Inc., and M. D. Pretorious, Sales Manager, G. M. Diehl Machine Works.

—Photos courtesy The Lumberman

PACIFIC NORTHWEST SECTION meeting participants May 7 and 8 in Eugene, Ore. included, left to right: R. M. Samuels, R. Quick, H. MacLean, P. S. Quelch, W. N. Pauley, Program Chairman R. W. Wellwood, S. M. Batori, W. Morss.

NEW PRODUCTS—LITERATURE

New Casein

A biologically stable casein which reportedly resists microbial spoilage and insect infestation has been developed by the Chemical Division of the Borden Company, 350 Madison Avenue, New York 17, N. Y.

The product contains a built-in preservative which cannot be leached out or extracted by an emulsified oil phase. It may be used as a binder or dispersing agent for pigments with no spoilage factor to be considered, it is reported.

The casein has excellent storage properties, mixes easily in water, and its solutions are dilutable with alcohols and glycols, it is claimed. The product is also said to be more readily soluble in water with alkalies than ordinary casein, can readily be cold cut without difficulty, and has excellent viscosity stability in solution. Samples of the product and complete technical data are available from the manufacturer.

Hydraulic Press Systems

A custom-built "Power Pak" which incorporates fluid power pumps, cylinders and valves for hot presses on a single reservoir base has been developed by The Oilgear Co., 1560 West Pierce St., Milwaukee 4, Wis. They are specially designed for use on foreign-made presses without hydraulic equipment.

The unit for an 1800-ton hot plate press has a reservoir base with a 2250-gallon total and 1600-gallon differential capacity designed to provide power and control for another similar press. Provisions for valving and tubing, plus mounting pads for installation of an additional unit, have been made to allow transformation of the reservoir base to a dual-press fluid power system.

The base, fully equipped, weighs 19,880 pounds, is 146″ long by 82″ wide by 110″ high, and is provided with seven clean-out covers and two inspection covers. An air breather on the base has a capacity of 550 cycles per minute.

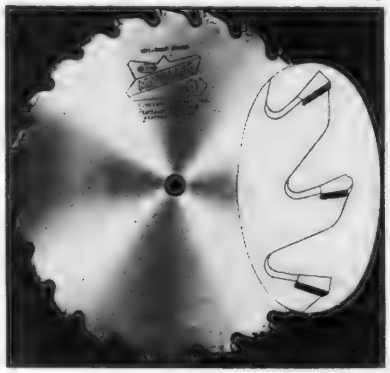
Materials Handling Unit

Another suggested use for Teco's engineered "tree" rack has been developed. This is by forming a continuous rack storage building by tying several "tree" racks together, in two rows, under a single roof. The rack was introduced last year to increase the usefulness of fork lift trucks in handling lumber and palletized or packaged building materials in short or long time storage, and in speeding up assembly of pick-up orders.

This latest use is illustrated in a folder, "Engineered Lumber Racks" which shows typical design No. 665, gives a list of materials for building the racks, as well as current and suggested uses. The folder is available without charge from Timber Engineering Co., 1319 18th St., N. W., Washington 6, D. C.

Carbide-Tipped Saws

A new line of carbide-tipped saws known as the Meyco Mainline Uni-Chip has been introduced by W. F. Meyers Co., Bedford, Ind. The new blades consist of alternating double-beveled and straight raker teeth, claimed to give long life in the cutting



teeth and smooth, chip-cleaning with the straight raker teeth.

The saws come in several diameters and with different numbers of teeth, specially designed for ripping, precision cutting, or for all-purpose cutting.

Contact Adhesive

A liquid, air-drying adhesive which reportedly bonds immediately and permanently upon contact without clamps or presses has been developed by National Casein Co., 601–619 West 80th St., Chicago 20. It is said to be especially suited for hard-to-glue jobs, where pressure is difficult to apply, where materials will not bond with ordinary glues, and where an instant bond on contact is necessary or desirable.

The contact-bond adhesive will glue plastic laminates to plywood and will bond wood veneers and other materials. The glue line is reported highly water resistant and withstands oxidation, oils, grease, and most chemicals.

EMPLOYMENT SERVICE

Positions Offered

No. E 223—Leading producer of wood preserving chemicals and solutions seeks man to train in research department for eventual transfer to sales or technical service work. Prefer recent graduate in wood technology or wood utilization. Salary commensurate with qualifications and experience, plus several fringe benefits. Position in south-central U. S. (July)

No. E 233—Large Midwest institutional furniture company seeks wood technologist and wood finishing laboratory technician. Prefer B.S. degree. Approximate salary range $500. Starting date, September. (Aug.)

No. E 234—Sales manager wanted to handle sales of modern automatic sawmill machinery through dealers and directly. Mechanical engineering or forest products degree preferable but not essential. (Aug.)

No. E–235—Several openings available on staff of an expanding industrial research and development laboratory, located in East. Consideration will be given recent wood technology or utilization graduates, as well as those having 5 to 10 years' experience in forest products fields. Heavy mathematics, engineering, or chemical background preferred.

Employment Wanted

No. 245—B.S. Wood Technology, U. of Minn., age 29, married. Four years' experience with U.S. Navy Bureau of Ships and timber laminating industry. Specializing in quality control. Desires quality control or working out procedure of glues and gluing for plant guidance. (Aug.)

No. 356—Forestry graduate seeks position as general manager or plant superintendent of a small mill. Has several years experience in supervisory capacity. Married, age 36, will locate anywhere. (July)

No. 358—Executive with extensive managerial experience in design, construction, installation, and operation of chip-core plants. (Aug.)

No. 359—Purchasing agent or sales engineer, nine years' experience. Presently with large chemical company serving New England state; previous experience in pulp and paper, creosote and lumber industries. Five years as forester and procurement agent. M.S., Yale Forestry School. Age 39. (Aug.)

No. 360—Wood waste utilization. B.S. Chem. Engr., M.S. Chemistry. Age 36, married. 15 yrs. experience rubber, hardboard, wood waste, chemical utilization, dissolving pulp, and wood particle board. Presently Asst. Plant Mgr. of wood particle board mill; full knowledge of wood gluing; familiar with all phases of wood particle board industry. Desires supervisory position in research, development, technical service, or production. (Aug.)

No. 361—B.S., botany major, age 33, presently primer shop engineer; five years' experience, design of new equipment, experimental work, quality control. One year as chemical control worker in explosives. Northeast. (Aug.)

No. 362—Supervisor, hardboard plant; B.S. forestry for wood production (honor graduate). Age 28, single. Presently located West Coast; assisted in pilot plant development of hardboard process for one-half year. Assisted in start-up of 150-ton hardboard production plant, one year. Two years production supervision. Has also had teaching and professional laboratory experience. (Aug.)

No. 363—B.S. Forest Mgt., N.C. State, 1950. 5-1/2 years experience in timber marking, field examination, some surveying, logging operations: desire location within 200 mile radius of central N.C. Will consider any opportunity related to forestry, utilization, sales, etc. (Aug.)

No. 364—Will graduate September, Wood Tech., N.C. State College. Prefer New England. Interested in particle board; thesis work concerned with "springback" in flat press boards. Desires research or management opportunity. Married. (Aug.)

No. 365—Wood Technology graduate B.S., U. of Minn., June '54. Age 23, single, excellent scholastic and employment record, veteran as of Sept. '56. Seeks research or production position. (August)

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Testing and Evaluating Procedures for Building Boards[1]

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Building fiberboards, which include the conventional, felted-fibrous insulation board and hardboard as well as resin-bonded wood-particle boards, must be evaluated for: quality control during manufacture, determination of strength and physical properties, purchase specifications, comparison with other materials, and engineering properties that may be used in design of structures. Test procedures are discussed for evaluating the strength and physical properties of boards alone or in combination with other materials in a composite construction.

Introduction

INSULATION BOARD and hardboard have been manufactured for many years. The time-proven uses for established products, with a few exceptions, have been developed largely by "cut and try" procedures. There have not been established performance requirements for the use or the material. Often building fiberboard of a certain quality has been used in a certain way. Experience proved it satisfactory, but there was no way of knowing how much too good it actually was or if a product of lower quality would be as satisfactory.

The increase in the production and the number of producers of insulation board and hardboard and the new particle board industry have made the need for more and better test procedures acute. New uses and additional classes or types of products accentuate the need.

At first appraisal, it would appear that separate procedures are needed for insulation board, hardboard, and particle board. It must be realized, however, that test procedures applicable to any type of board are needed because the different types of boards have overlapping use. Certain board products cannot clearly be classified as either a fibrous-felted product, such as conventional insulation board and hardboard, or a resin-bonded particle-type board. Much confusion would result if conventional hardboards were evaluated by one group of test procedures and particle-type hardboards intended for the same use were evaluated by an entirely different set of test procedures.

In the past, building fiberboards have had only limited use as structural material. Consequently, test procedures were developed without recognition of the requirements for an engineering material. If building fiberboards are good engineering materials, then they should be evaluated as such. For this reason, there must be a change in testing procedures from those satisfactory in the past to those which will do the job in the future.

This paper will discuss the need for such procedures and the progress made in the development of proper test procedures for the different needs. Sources for many of the procedures will be given.

Requirements for a Quality Control Test Procedure

Every manufacturer of an insulation-board, hardboard, or particle-board product needs a series of test procedures for quality control purposes. These procedures should allow him to manufacture his product within the limits of quality that will assure maximum profit and yet assure him that the lower limit of quality will be above the minimum required by specification and use. To be practical, a quality control test should satisfy the following conditions as nearly as possible.

1. The procedure should require a minimum of time so that any correction necessary in the manufacturing process can be made with the loss of a minimum of low-quality material and the production of a minimum amount of board of better quality than required.

2. The equipment needed for a particular test should be relatively simple and require a minimum of adjustment for the different products regularly manufactured in a particular plant.

3. The test should be sufficiently sensitive and accurate so that test values will reflect changes of quality of manufacture and so that "go, no go" limits can be set.

4. The test should measure some particular quality of the board, such as strength, distribution of sizing, or bond, so that changes in production can be made to correct variations in quality control values.

5. Quality control tests should be simple enough to be made by regular mill personnel.

It is desirable that test procedures for quality control give results that can be compared with the minimum values of applicable specifications. It is common belief that if the test procedure required in a specification is the same as that used in the quality control tests, the values obtained will be comparable. Since building fiberboards are composed of wood substance, they are hygroscopic, and test values are dependent upon the moisture content and the distribution of moisture in the board at time of test. Freshly manufactured board does not have the same moisture content as when it is delivered. Since moisture gradients are established by hot pressing and drying, the distribution of moisture in a board is not uniform. For these reasons, the values from the quality control tests made soon after manufacture will not be the same as those obtained later on a shipment of board for compliance with specifications. Thus, a correction factor should

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[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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be established for each kind of quality control test to equate the values obtained at the factory to those obtained at the time of delivery or use.

Because such a correction factor is necessary and because quality control tests should reflect only differences in manufacture, it is possible to develop a program based on each type of product. This paper considers test procedures for the final boards only. During manufacture, no consideration is given to the tests of components, such as freeness of pulps or sieve analyses of particles.

Requirements for a Specification Test Procedure

Quality control tests are needed to indicate to the manufacturer that the quality of manufacture is within the limits he has set for his product. By the same token, specification test procedures are needed to assure the purchaser and user that the quality of the building fiberboard meets the standards for the material. Test procedures, though influenced by quality control procedures, should be based on the following tenets:

1. Tests should reflect differences in quality that have a direct relation to use.
2. The tests themselves should be practical to make on a per shipment basis.
3. Since most test procedures require cutting up finished panels, the number of boards required for test should be kept low to reduce waste of finished boards.
4. Test procedures should give results that classify boards by type so that in a competitive bidding situation only those types of board known to be satisfactory for a particular use will comply with values obtained from the tests.

Most test procedures included in present specifications for building fiberboards are similar to those used for quality control in the plants where the boards were made. As the uses for fiberboards become more varied and the strength and physical properties become more important, the test procedures for specifications will of necessity be revised and refined.

Also, some test procedures that reflect engineering properties, such as thermal conductivity or dimension change at different equilibrium moisture contents, may be either relatively expensive or time-consuming. Since the properties are more closely related to process than day-to-day production, it may be feasible for specifications to require certification as to certain properties rather than to test each shipment for compliance. More and more manufacturers of building fiberboards are setting up excellently engineered quality control programs based on statistical analysis of an adequate number of samples. Because such a sample is much more representative of the quality of production than a small sample based on a single shipment, specifications may permit the substitution of certification for routine tests. In this case, correlations must be established between the test values obtained at the factory and after delivery.

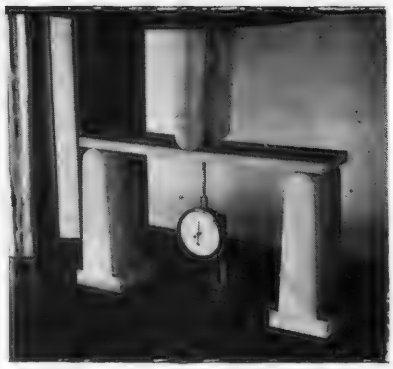

Fig. 1.—Test assembly for static bending (flexure).

Requirements for Test Procedures for Engineering Evaluations and Similar Uses

Some test procedures for quality control work and specifications are a compromise between the ideal and the practical. Refinements in test procedure are necessary to obtain values that can be compared with other engineering materials, to determine properties that are critical in actual use and to use in research or engineering design. Simplified equipment may be used for such routine testing as quality control, but for engineering evaluations, accurate testing equipment is essential.

For mechanical tests, the testing machine head speed is most important, because the faster the test the higher will be the test values. With mechanical weighing systems, the effects of inertia may be appreciable at high loading speeds. The result is a test value that is higher than it should be for that loading speed.

Basically, an engineering or research test procedure should satisfy the following requirements:

1. Values should be accurate to the same number of significant figures reported in the test and required by it.
2. Values should be comparable with those obtained for other qualities and thicknesses of the same types of board.
3. Values should be reproducible when the procedure is followed by different investigators in different places.
4. Values should be comparable to those obtained for other materials, such as wood, plywood, and other sheet materials.
5. Values should clearly relate to use conditions or be readily translated into terms that will relate to use.

Any test program for building fiberboard should recognize the limitations of the procedures used. The need for the test and the use of test results should meet the requirements outlined for the different types of tests. Each type of test fulfills an important need, but the limitations should be recognized.

Organizations Promulgating Test Procedures for Building Fiberboards

Test procedures for building fiberboards are detailed as a part of various specifications for board products and as methods of test by organizations primarily interested in testing standards. The American Society for Testing Materials (ASTM), Philadelphia, Pa., has the most comprehensive test procedures for insulation board, hardboard, and particle board, which are included in the methods and standards deevloped by various ASTM committees. Each of these committees represents producer, general-interest, and consumer groups.

Test procedures pertaining to building fiberboards are found in the following tentatives and standards of ASTM:

1. D1037–55T, Methods of Test for Evaluating the Properties of Building Fiberboards.
2. E72–55, Conducting Strength Tests of Panels for Building Constructions.
3. C355–54T, Water Vapor Transmission of Materials Used in Building Constructions.
4. C177–45, Thermal Conductivity of Materials by Means of the Guarded Hot-Plate.
5. C209–55T, Methods of Test for Structural Insulation Board Made from Vegetable Fibers.

The test procedures of method D1037–55T are designed for evaluating the newer resin-bonded wood particle boards as well as the conventional felted-fibrous insulation boards and hardboard.

The American Standards Association may accept as American Standard certain test procedures of ASTM after they have been used and accepted as standard by the Society. None of the five listed has been so accepted to date. The Technical Association of the Pulp and Paper Industry (TAPPI), New York, through its technical committees, also develops test procedures

that pertain to building fiberboards manufactured from pulps. The only test procedure directly applicable to finished board is T1003–SM53, Quality Control Flexure Test for Insulating Fiberboard. Other TAPPI procedures pertain to the boards during manufacture.

Test procedures are included in the Commercial Standards and Federal Specifications for Building Fiberboards. Pertinent standards and specifications detailing test procedures include:

1. Federal Specification, Hardboard, Fibrous-Felted (Fiberboard), LLL–H–35, Dec. 21, 1955.
2. Interim Federal Specification, Fiberboard; Insulating, LLL–F–321C.
3. Federal Specification, Acoustical Units; Prefabricated, SS–A–118b, Aug. 4, 1954.
4. Federal Specification, Wallboard; Composition, UU–W–101a.
5. Commercial Standard, 176–51, Prefinished Wall Panels.
6. Commercial Standard, 112–43, Homogeneous Fiber Wallboard.
7. Commercial Standard, 42–49, Structural Fiber Insulating Board.

Details of Standard Testing Procedures

Although primarily concerned with engineering test procedures, this section of the paper includes a survey of quality control and specification procedures. The following sections discuss the particular procedures themselves.

Specific Gravity (Density): Whether it is used to measure quality of manufacture or to determine cost of shipping, the density of a particle board is an important physical property. The specific gravity of a board may be determined by testing small specimens cut from a large panel or by measuring and weighing the whole panel.

It is common practice to determine the specific gravity of all static bending specimens and other test specimens when needed in the evaluation of a building fiberboard. Since the bending specimens are rectangular in shape, they are carefully measured and weighed. Moisture content determinations are made on a part of the specimen after test, and the specific gravity is calculated from the weight of the specimen corrected to 0 per cent moisture content and the dimensions at test. Specific gravity is therefore on the basis of volume at test and oven-dry weight. This method is detailed in sections 69 and 70 of ASTM D1037–55T.

Occasionally, specific gravity is calculated on an "as is" basis, that is, weight and volume at the time of measurement. In this case, values are expressed in terms of volume and weight at test, and it is necessary to know the moisture content also if values are to be considered as other than relative.

It is common practice as a part of a quality control program to weigh and measure complete panels as they come from the drier or press. Specific gravity is an important indication of quality for any process. Changes in quality of production are indicated by a change in the density of a board. Variation in quality within a panel is indicated when panels are sawed into small specimens and the specific gravity of each specimen is determined.

Static Bending (Flexure): Static bending tests of one sort or another are common in all specifications, evaluations, and quality control test programs. From an engineering standpoint, the procedure outlined in sections 10–19 of ASTM D1037–55T has the greatest degree of refinement and yields values nearest to the absolute. In the static bending test, specimens are loaded as simple beams under center loading. When load-deflection data are obtained during test, the modulus of elasticity (stiffness), stress at proportional limit, work (area under load-deflection curve), and modulus of rupture can be calculated. If only the maximum load is determined, only the modulus of rupture can be calculated.

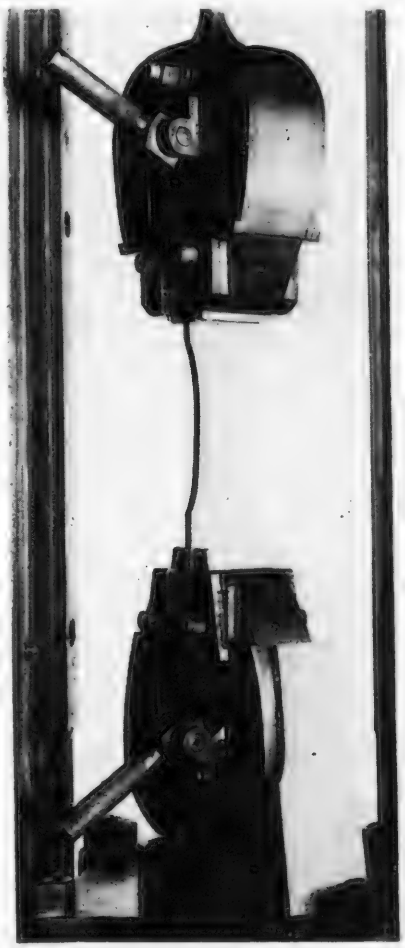

Fig. 2.—Setup for testing tension parallel to surface.

The principal differences between the procedure outlined in D1037–55T and methods required by other specifications are in degree of refinement in the test itself. In D1037–55T, a constant ratio (24) is required between the span and depth, while in the other tests, the same span is used for different thicknesses of board. With a constant span-depth ratio, values from tests of different thicknesses of board are comparable. This is not strictly true, however, if span is not varied with thickness. Fig. 1 shows the test assembly for static bending.

Another difference between D1037–55T and other procedures is test speed. The testing speed, which is based on a constant rate of fiber strain, is slow enough so that sufficient load-deflection data can be obtained and test values can be compared to those of similar tests on other materials, such as wood, plywood, or other sheet materials. Since the other test procedures were evolved from techniques for testing paper, they are based on much faster testing speeds that have little relation to those used for other engineering materials.

The quality control procedure in TAPPI 1003–SM53 was developed primarily for insulation board and is based on a study of the effects of loading speed on that material. The study indicated that more uniform values were obtained at slower loading rates than at faster ones. A 1-minute test was considered practical for quality control purposes, and values were not significantly different from those obtained at the speeds required by the D1037–55T procedure.

Tensile Strength Parallel to the Surface: Tests of tensile strength parallel to the surface, which are outlined in sections 20 to 26 of D1037–55T, are made on specimens nominally 2 inches wide and 10 inches long with a sawed center section reduced to 1½ inches wide by 2 inches long (Fig. 2). A transition section with a 3-inch radius is located between the center section and the 2-inch-wide ends. This reduced section is required to assure that failure will occur in the center section and not be influenced by the grips. Squeezing by the grips with the attendant stress concentrations produces a high percentage of failures at or near the grips if a straight-sided specimen is used.

Specimens are held in self-alining grips (Fig. 2), and loads are applied by separation of the heads of the testing machine at a rate of 0.15 inch per minute.

Tests of tension parallel to surface strength in other specifications are generally similar. As in the static bending test, testing speeds are faster since they have ben evolved for quality control tests and for use with modified paper testing machines.

Tensile Strength Perpendicular to Surface: Tests of tensile strength perpendicular to surface, which are outlined in sections 27 to 32 of D1037–55T, are made on specimens 2 inches square. Metal loading blocks are glued to the faces of the specimen (Fig. 3). This is a most important test for hardboards and particle boards, since it measures the quality of the bond in the board. The metal blocks can be successfully glued to the specimen with any adhesive that provides a bond between the specimen and the blocks that is stronger than the bond in the board. Room-temperature-setting epoxy resins have proven adequate for all boards manufactured to date.

The specimen is loaded at a rate of separation of the testing machine heads of 0.08 inch per inch of thickness per minute. Unit tensile strength is the maximum load divided by the cross-sectional area of the specimen. Meal blocks are specified because experience has shown that wood blocks may change dimension and shape between the time the specimens are glued and tested, thus adversely affecting test values. Fig. 3 shows the test assembly.

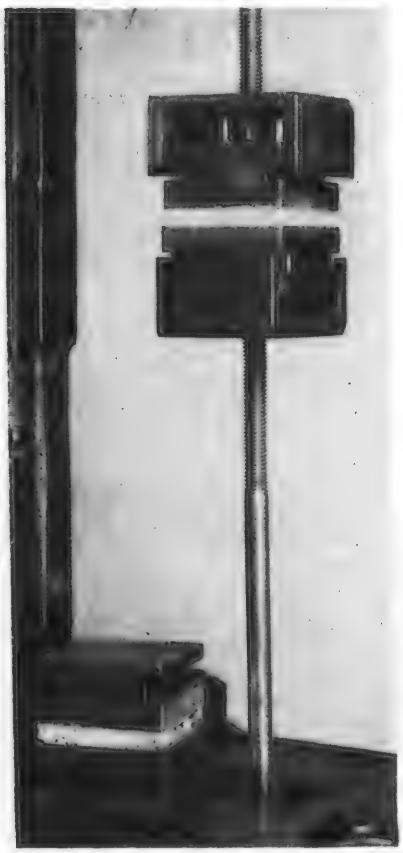

Fig. 3.—Setup for testing tension perpendicular to surface.

Fig. 4.—Setup for testing lateral nail resistance.

Lateral Nail Resistance: For certain uses, particularly in housing, the resistance of a board to lateral movement of a nail or other mechanical fastening is important. The lateral nail resistance test, which is outlined in sections 33 to 38 of ASTM D1037–55T, measures that property. The test is made as shown in Fig. 4. Nails driven through the board at distances of ¼, ½, or ¾ inch from the edge are moved laterally. The measure of lateral resistance is the maximum load required to move the nail. The testing machine speed is 0.25 inch per minute.

Direct Nail Withdrawal: The resistance of a building fiberboard to direct nail withdrawal is measured by the force required to pull a nail from the board. Sections 39 to 45 of D1037–55T outline the procedure. Fig. 5 shows the test assembly. The rate of withdrawal is 0.06 inch per minute.

Hardness: The Janka ball hardness test is usually used to measure the comparative hardness of a building fiberboard. Since it is the standard test for wood, values are comparable to those published for the different species of wood. In the Janka ball test, the load required to embed a ball of 0.444-inch diameter (1 square centimeter projected area) to one-half of its diameter is the index of hardness. If the board being evaluated is less than 1 inch thick, two or more thicknesses must be laminated to provide a specimen thickness of at least 1 inch. A rubber or other flexible adhesive is used so that the glue lines will not affect the test results appreciably.

Tests are made as detailed in sections 46 to 51 of D1037–55T, with a tool like that shown in Fig. 6. The tightening of the collar indicates the penetration of one-half the diameter. The testing machine head speed is 0.25 inch per minute.

Water Absorption: Water absorption has been considered an important test for board for many years, and maximum allowable absorption values are a part of all present specifications. Originally, it was the means of determining the distribution of sizing in conventional insulation board and hardboard. If sizing was not uniform or absent, water absorption values were high, and the mismanufacture was noted. This test is still important because it measures the moisture uptake in a board caused by occasional or short-time wetting. However, it is not a measure of the ultimate takeup of moisture. At equilibrium, most boards will soak up much more water than is indicated by the 2-hour soak test for insulation board or the 24-hour soak test for other boards.

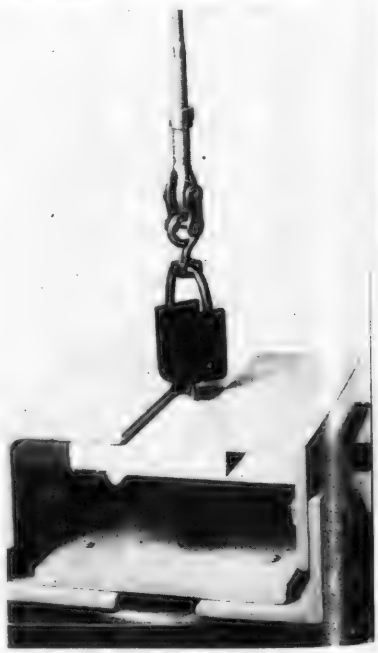

Fig. 5.—Setup for testing direct nail withdrawal resistance.

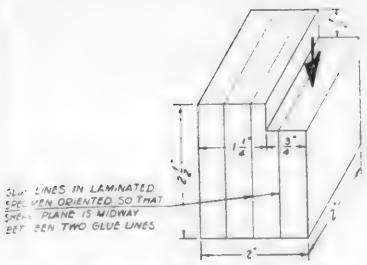

Fig. 7.—Detail of specimen used to test shear parallel to surface.

This test is made as detailed in sections 52–58 of D1037–55T by measuring the change in weight of a 12-inch-square specimen after soaking in water.

Linear Variation with Change in Moisture Content: Linear expansion or contraction with changes in moisture content caused by changes in relative humidity is one of the most important properties of a board. Practically all boards are subjected to at least seasonal changes in relative humidity in use. Unfortunately, this test cannot be made quickly because of the time required for a board to come to equilibrium moisture content at different relative humidities. The test may require several months.

The test is made as outlined in sections 59 to 62 of ASTM D1037–55T. Extremes of exposure for the test are 30 and 90 per cent relative humidity. The change in length at equilibrium between the two relative humidities is expressed as a per cent of the length at 50 per cent relative humidity.

Because of the time lapse between start and end of test, this procedure, unfortunately, is of little use in quality control. Some manufactures, realizing the importance of linear expansion with changes in moisture content, measure the change in length before and after a 24-hour soak. After a correlation is obtained for each of their products between the fast test and the D1037 test, they have a good indication of how their day-by-day production will behave.

Accelerated Aging: If a board material is to be used in severe exposure conditions, such as prevail on exterior siding or wall and roof sheathing in a house, its durability is an important property. The accelerated aging exposure of sections 63 to 67 of ASTM D1037–55T was developed by the National Bureau of Standards to obtain a measure of the durability of materials for many years of service in such applications as housing. In the test, static bending or other test specimens are submitted to cycling. Each cycle consists of the following:

1. Immersed in water at 120° ± 3° F. for 1 hour.
2. Sprayed with steam and water vapor at 200° ± 5° F. for 3 hours.
3. Stored at 10° ± 5° F. for 20 hours.
4. Heated at 210 ±° F. in dry air for 3 hours.
5. Sprayed again with steam and water vapor at 200° ± 5° F. for 3 hours.
6. Heated in dry air at 210° ± 3° F. for 18 hours.

After six complete cycles, the test specimens are conditioned at 65 per cent relative humidity before testing. The test values obtained from the artificially aged specimens are compared with those from tests of specimens not subjected to such exposure.

Other Tests of Board Materials

The U. S. Forest Products Laboratory, in evaluating insulation board, hardboard, and particle board, uses several tests in addition to those outlined in ASTM D1037–55T. Some of them will shortly be incorporated in the ASTM method. Others are for some special property that is not usually needed, and still others require specialized equipment that is not generally available. The following procedures fall into these three groups.

Shear Strength Parallel to Surface: The standard block shear test for wood parallel to grain, which is outlined in sections 88 to 92 of ASTM method D143–52, "Tests for Small Clear Timber Specimens," has been adapted for use with building fiberboards. The specimen is 2 by 2 by 2½ inches, with the 2½-inch dimension parallel to the shearing direction. The specimen has a sawed ½- by ¾-inch notch so that the shear area is 2 inches square. Since boards are usually less than 2 inches thick, it is necessary to glue several thicknesses together to obtain the necessary thickness. The specimen is detailed in Fig. 7.

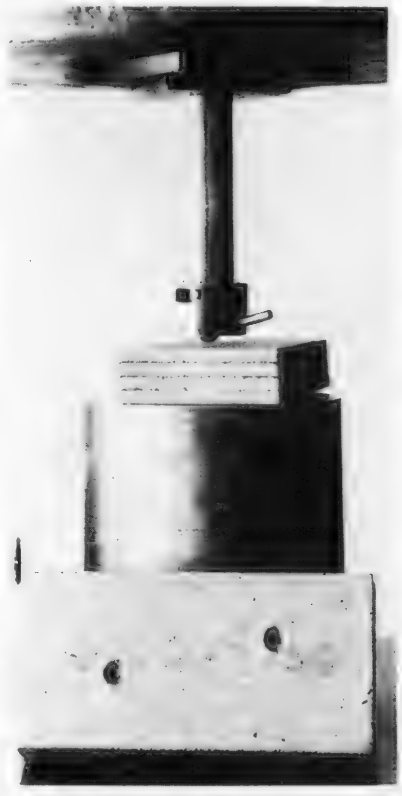

Fig. 6.—Setup for testing hardness.

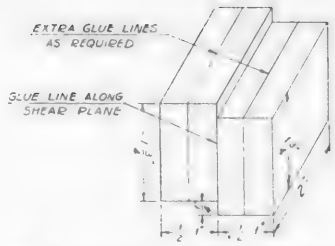

Fig. 8.—Detail of specimen used to test glue line shear.

Glue lines are oriented so that the shear plane is midway between two glue lines. Specimens are sheared in the standard loading tool used for wood. The procedure will probably be incorporated in ASTM D1037 method during the coming year.

Glue Line Shear Strength: Since boards of all types may be glued to themselves and to other materials, the strength of glue lines in shear is becoming increasingly important. The glue-line shear specimen for wood and glued-wood constructions has been adapted for measuring glue shear in particle or other boards. This is a double notched specimen (Fig. 8) 1 to 2 inches thick, which is made by gluing an even number of pieces together so that the glue line along the shear plane is in the center of the specimen. The specimen is 2 inches wide and 2 inches long.

The test is made as outlined in sections 64 to 67 to ASTM D805–52, "Methods of Test for Veneer, Plywood and Other Glued Constructions." Tests are made by shearing the specimen along the glue line in the shear tool, which is detailed in Fig. 18 of D805–52. Unit shear stress is calculated from maximum load. The percentage of fiber transfer in the failure is estimated.

Direct Screw Withdrawal: The resistance to screw withdrawal is an important property when particle boards are used alone or as core for veneered or plastic-overlayed construction in furniture and millwork. The same apparatus is used as for the direct nail withdrawal test, except that a screw instead of a nail is pulled from the specimen. Either a 1-inch-long No. 10 wood screw or a 1-inch-long No. 10, type B, sheet-metal screw is used for

the test. The screw is embedded $\frac{2}{3}$ inch, which is the length of threaded portion of a wood screw. Lead-hole diameters vary with the density of the board. The American Wood Screw Manufacturers Association recommends lead-hole diameters of two-thirds the root diameter for low-density species and nine-tenths of the root diameter for high-density species of wood. Thus, the density of the board should govern, and the report of the test should specify the lead-hole diameter used.

Nailhead Pullthrough: The resistance of a building fiberboard to the pulling through of a nailhead may be a desirable property if a board is nailed to a framework, such as studding in a house. If the board is used as paneling, the fastening may be a set finishing nail. If insulation board is used as sheathing, a large-headed nail may be driven flush with the surface of the board.

The nailhead pullthrough test is made on nails or other fasteners driven through the board and set to simulate the projected use. The point of the nail is engaged by a toggle-connected key-type drill chuck or the jaws of a tension grip, and the specimen is supported with the nail centered over a 3-inch-diameter orifice. The head is pulled through the board at the rate of 0.06 inch per minute, which is the same as for the direct withdrawal test. The maximum load is the measure of resistance.

Compression Parallel to Surface: For certain engineering applications, the compression strength of a board parallel to the surface is an important property. In order to obtain the true measure of the compression strength, it is necessary that the specimen fail as a short prism without buckling.

Since hardboards and some particle boards are relatively thin, the pack test is used. In this test, the specimen, which is 1 by 4 inches by the thickness of the board, is supported laterally against buckling during the test. The procedure is the same as that specified for plywood in sections 4 to 9 of ASTM D805–52 for veneer, plywood, and other glued constructions. The apparatus for maintaining the lateral support during test is detailed in Fig. 2 of D805–52.

Impact Tests: Shock resistance is an important property in many applications. The U. S. Forest Products Laboratory toughness machine is a single-blow impact machine based on the pendulum principle. The size designed for testing regular-size specimens of wood, which is detailed in sections 71–76 of D143–52, is used for boards with a thickness of $\frac{3}{4}$ inch or more. A smaller size, which is detailed in sections 43 to 48 of D805–52, is used on thinner material.

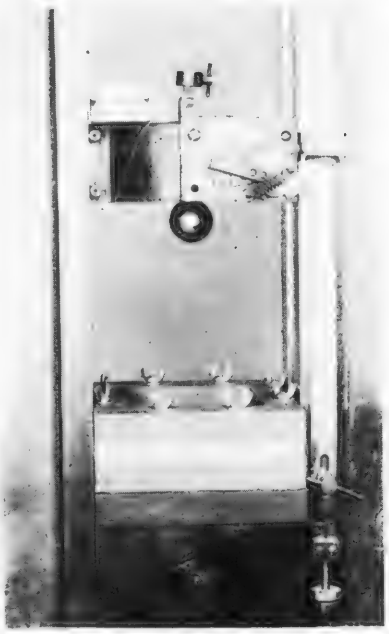

Fig. 9.—Setup used in falling ball impact test.

In either test, the energy required to fail the specimen is calculated from the difference between the initial and final angles of the pendulum. Values obtained from any single-blow impact test are relative. They can be used only for comparisons and not directly in design.

Another impact test is the falling-ball test in which a 2-inch-diameter steel ball weighing 1.18 pounds is dropped on the specimen supported as a panel. Successive drops are made from increasing heights in 2-inch increments until the specimen fails. The height of drop that produces visible failure on the tension face is taken as the measure of impact resistance.

Fig. 9 shows the test setup used at the U. S. Forest Products Laboratory. The panel tested is 9 by 10 inches, with an unsupported center area 6 inches square. As with the toughness test, values from this test are relative. A board that sustains a drop of 24 inches at failure is not twice as resistant to impact as one that fails from a 12-inch drop.

Abrasion Resistance: For some uses, the abrasion resistance of the surface of a board may be important. Values for uniform wear (abrasion) on wood are available.[3] These values were obtained by using the Navy wear tester,[4] which simulates the scuffing action of walking feet. Consequently, the same procedure is used for building fiberboards.

The machine is too complicated to describe in detail in this paper. Specimens are 2 by 4 inches, and the area abraded is 2 by 3 inches. Wear or reduction in thickness is measured every 100 revolutions of the abrading disk. A fresh supply of No. 16 aluminum oxide grit insures reproducibility of results and comparability of different tests. Results are presented as wear per 1,000 revolutions.

Special Tests: Test procedures for measuring such properties as vapor permeability, sound reflection, thermal conductivity, and dielectric strength are standard tests regardless of the material. As a rule, these tests require special equipment not readily available in most laboratories. Some can be made in only one or two places in the country. Special procedures have been developed and are included in ASTM standards.

Tests of Composites Using Building Fiberboards

The number of possible uses for insulation board, hardboard, and particle board in conjunction with other materials is practically infinite. It would not be possible in any paper to mention, much less detail, all of the tests that can be made. Generally speaking, tests of composites are built around use requirements of the finished consrtuction. Doors are tested as doors regardless of whether they are a six-panel Colonial door of solid wood or a solid-core flush door with particle board core and hardboard faces.

The one exception is probably extruded particle board, which usually has a veneer crossband or paper overlay applied soon after manufacture to stiffen it and facilitate handling. The trend will probably continue, and flat-platen pressed particle board will be merchandised with overlays or crossbands already laminated to the board. In this case, tests of the composite should follow closely the procedures for the building fiberboard itself.

Additional uses for insulation board, hardboard, and particle board will depend to a considerable extent on proper evaluation of the boards and proper understanding of their properties. When fiberboard is used with other materials, it will also be important to understand how the fiberboards and other materials affect each other.

[3] Youngquist, W. G., and Munthe, Bert P. 1948. The abrasive resistance of wood as determined with the U. S. Navy wear-test machine. U. S. Forest Products Laboratory Report No. R1732. 23 pp.

[4] Available commercially from Tinius Olsen Testing Machine Co., 500 N. Twelfth St., Philadelphia 3, Pa.

Effect of Temperature Variation on the Results of the Cyclic Exposure Test for Glue Bond Durability[1]

C. ARTHUR HART

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Results indicate how increased temperatures, such as those occurring in seasonal variations from winter to summer, greatly increase the severity of the cold soak for delamination test for evaluating plywood glue bond durability.

THREE LEVELS OF GLUE BOND DURABILITY are differentiated in the Commercial Standard CS35–49 entitled "Hardwood Plywood". These three levels are:

1. Fully waterproof bond (for Technical and Type 1 Plywood)
2. Water-resistant bond (for Type II Plywood)
3. Dry bond (for Type III Plywood

The test for a fully waterproof bond utilizes the well-known plywood shear test specimen and incorporates both a cyclic wet and dry test and a cyclic boil test, with half of the specimens subjected to the first treatment and the other half subjected to the second treatment. Mechanical shear testing by the plywood shear testing machine follows the cyclic exposure. Performance must meet minimum requirements in both percentage of wood failure and in strength of shear value, measured in terms of pounds per square inch.

The test for a water-resistant bond (for Type II plywood) utilizes a 6-in. by 6–in. test specimen. This test is referred to as a "cold soak for delamination" test since a treatment cycle consists of soaking in water followed by a period of drying, with satisfactory performance being indicated by the absence of delamination or separation of the plies at the glue line.

The dry bond (for Type III plywood) requires no test.

This paper is concerned with the test for the water resistant bond, which incorporates the 6-in. by 6-in. test specimen. This type of test is widely employed for determining the quality of glue bond in the intermediate durability range. Various specifications differ as to exact details, but in general the test consists of soaking the test specimens in water at room temperature for a period of four hours and then allowing the specimens to air dry for 20 hours, which completes one cycle. In most instances the specimens are examined for delamination at the completion of each cycle.

Index to Durability

Continuous delamination of any given glue line in excess of 2 inches on any edge constitutes failure of that specimen, and the number of cycles successfully completed serves as the index to the durability of the glue bond. Specifications may require that a given percentage of the specimens successfully complete a minimum number of cycles or may require that the average number of cycles passed by all specimens be beyond a given minimum. In the latter case it becomes necessary to establish a maximum limit beyond which the cycles need not be conducted, otherwise the testing might have to be continued almost indefinitely. In many applications this maximum assignable value for any given specimen is established as 15 cycles and the required minimum average established as 10 cycles. CS35–49, Hardwood Plywood, requires only two cycles but in other respects the test as quoted from it is typical of the tolerances required in control of the variables involved in the test.

"One specimen, 6 in. by 6 in., from each test piece from each sample panel shall be submerged in water at room temperature for a period of 4 hours, and then dried at a temperature between 70°F and 100°F for a period of 20 hours. The cycle shall be repeated, after which the specimens must not show a visible delamination between any two layers of veneer totaling more than 2 in. in continuous length and over 1/8 in. in depth at any point."

Three variables which demand immediate notice upon a careful examination of these specifications are temperature, humidity, and air velocity. Temperature is specified as room temperature for soaking and between 70° F. and 100° F. for drying. No mention is made of either humidity or air velocity.

Affect Drying

These three variables control both the rate of drying and the extent of drying. They may, in addition, exert their own individual effect. For example, some glues may be very sensitive to increased temperatures as compared to other glues. Lower humidities may appreciably increase the severity of the test by producing lower moisture contents and thereby greater shrinkage stresses.

However, it is not contended at this time that all of these variables warrant closer control than those specified in the commercial standards. It is contended, however, that no given variable should be uncontrolled unless its effect is known and has proven to be of no serious importance. Such has not been the case in the specifications drawn up for the cold soak for delamination test. At present, the temperature variable is being investigated and the results from the following preliminary experiment indicate its importance.

Since the temperature within the testing area of a plant may easily vary from less than 70° F. in winter to more than 95° F. in summer, it was felt that these two temperatures of 70° and 95° would provide a representative range for the experiment. The principal question to be answered was whether or not the number of cycles a specimen would successfully complete when soaked and dried at 70° would differ significantly from the number of cycles it would complete when soaked and dried at 95°. A second question was the relative importance of the temperature of the

[1] Entered in Graduate Division, 1955 Wood and Wood Products Award, sponsored annually by Wood Publishing Corp., Chicago.

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water for soaking versus the temperature of the air for drying. This led to four temperature combinations for a cycle:

1) 70° F. soaking with 70° F. drying—70/70
2) 70° F. soaking with 95° F. drying—70/95
3) 95° F. soaking with 70° F. drying—95/70
4) 95° F. soaking with 95° F. drying—95/95

The designations following the dashes were used throughout the study to indicate temperature combinations. The soaking temperature logically precedes the drying temperature in this designation since soaking precedes drying in a cycle. The relative humidity of the air at each of the two air temperatures was controlled to give a constant equilibrium moisture content of 9% based on oven dry weight. Thus the specimens in either of the drying conditions were dried to the same extent so this variable was not confounded with the temperature variable.

The plywood panels from which the test specimens were cut were glued with a hot-press liquid urea-formaldehyde resin which was a typical commercial brand. A press temperature of 250° F. was used. Both core and face veneers were rotary cut 1/16-inch red gum (*Liquidambar styraciflua* L.) sapwood, conditioned to a moisture content of 9% (based on oven dry weight). A three-ply construction was used. Practical considerations limited the size of the panels to 13" by 26", which permitted the cutting of eight 6" by 6" specimens from each panel. Two panels were simultaneously glued in each pressload.

The glue was extended 100% with wheat flour (based on 60% glue solids). In order to insure, insofar as possible, a range of quality which would include the 10–to–15 cycle quality, the amount of glue spread was varied from 23 lbs. to 13 lbs. per thousand square feet of single glue line.

From preliminary investigations preceding the design of this experiment, it was noticed that in a test specimen of 3-ply construction and 1/16-inch veneer, delamination consistently occurred on one or the other of the edges parallel to the grain on the face prior to failure on either of the remaining two edges.

The explanation of this occurrence may be best understood by an examination of Fig. 1c. In this exploded illustration of a 3-ply specimen, the edge labeled by X is the edge parallel to the grain of the face and back plies while the edge labeled by Z is parallel to the grain of the center ply. When wetted, the plies tend to swell in the tangential direction, or across the grain, as indicated by the forces F_1, F_2, and F_3. These three forces are of approximately equal magnitude since the plies are of equal thickness. The force F_2 is restricted by the two glue lines which bond the core to both the face and back plies. Thus each glue line must absorb only one-half of F_2, which is in the direction of the Z edge. But on the X edge, the top glue line must absorb all of F_1 and the bottom glue line all of F_2. Thus each glue line is much more likely to delaminate on its X edge since approximately twice as much stress perpendicular to edge is placed upon it there.

Ordinarily, a test specimen is considered to have failed when delamination in excess of 2 inches occurs on any one of the four edges. In the construction employed here, however, the two edges parallel to the face grain were expected to fail before either of the two remaining edges, which are parallel to the grain of the center ply. Also, the failure of the first of these two edges parallel to the face grain is unlikely to affect the number of cycles which the second edge completes, since these two edges are six inches distant from one another. In this manner, two independent and unbiased experimental values may be obtained from the same test specimen.

In addition to providing two experimental results for each test specimen instead of only one, the panel construction described above also lends itself easily to a method of pairing the comparison between two test speci-

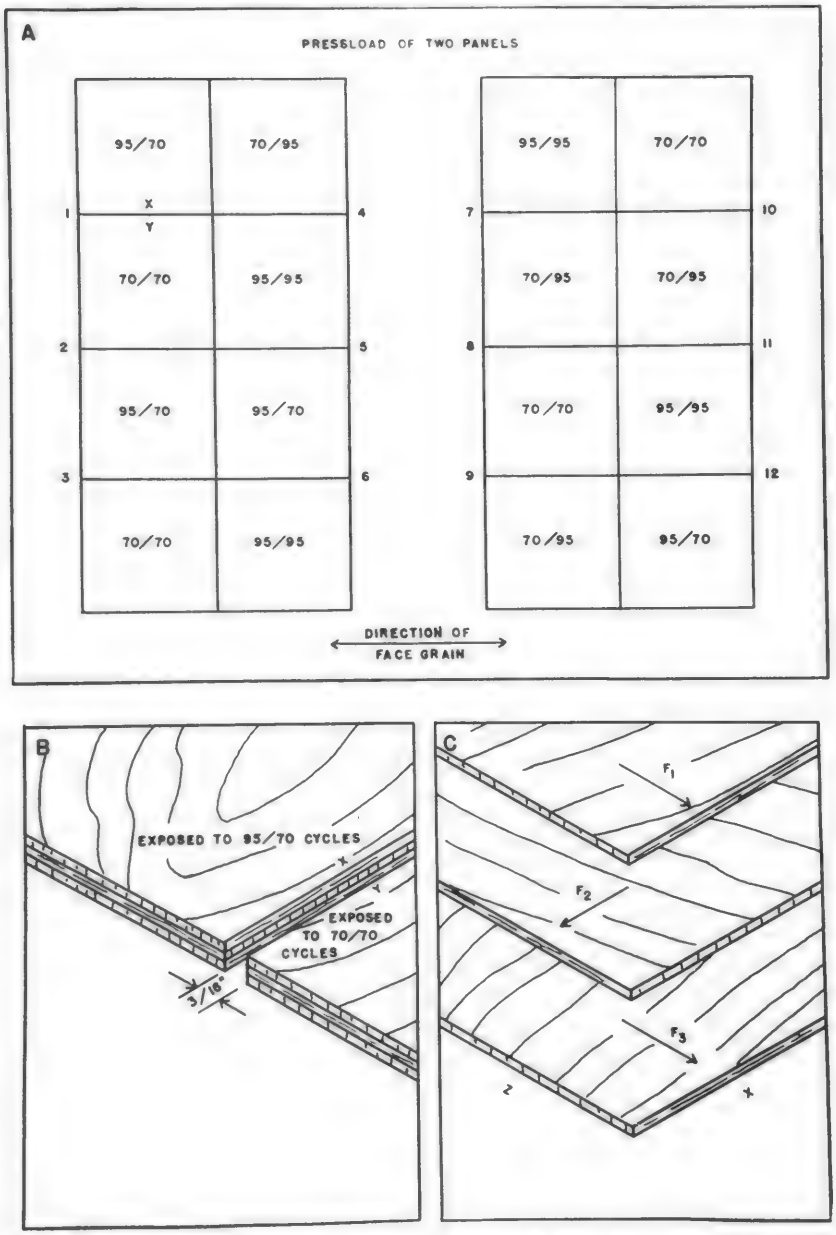

Fig. 1.—Selection of test specimens from panels: A. Method of selecting paired edges from test specimens; B. Illustration of paired edges; C. Exploded view showing direction of the forces of tangential expansion.

mens subjected to different temperature treatments. Figure 1a illustrates the manner in which this pairing technique was employed. This illustration represents a full pressload of two panels. Eight test specimens were cut from each panel. The top and bottom edges of each test specimen were expected to fail prior to the remaining two edges, since they represent the X edge as illustrated in Fig. 1c. The bottom edge of one specimen is separated only by a 3/16" saw kerf from the top edge of the next specimen. Thus one would expect the quality of two edges to be in closer agreement than the quality of two edges more widely separated.

From Fig. 1a it may be seen that there are twelve such comparisons per pressload, as labeled along the edges of the panels. Fig. 1b illustrates a closer view of the first pair, in which the edge of a specimen subjected to the 95/70 treatment is paired with the edge of a specimen subjected to the 70/70 treatment. It was felt that this arrangement would appreciably increase the precision of measuring the difference between treatments.

As illustrated in Fig. 1a, four comparisons were made directly:

70/70 vs. 70/95—pairs 8, 9, 10
70/70 vs. 95/70—pairs 1, 2, 3
95/95 vs. 95/70—pairs 5, 6, 12
95/95 vs. 70/95—pairs 4, 7, 11

Each comparison was replicated three times within a pressload and the comparisons were randomly distributed insofar as the design permitted. Thus the 20 pressloads provide 60 replications for each of the four direct comparisons, although this did not guarantee 60 useful replications, since some specimens might fail to pass one cycle while others might extend beyond the length of time it was desired to run the experiment.

The comparison between 70/70 and 95/95 was made indirectly through the fact that each was compared directly not only with 70/95 but also with 95/70. This furnished two independent estimates of the comparison between 70/70 and 95/95.

An air-conditioned room and an air-conditioned chamber provided the controlled conditions for the experiment. For the soaking part of the cycle, the specimens were placed in wooden racks which provided for the separation of each specimen from the next to insure uniform access to the water. Drying was accomplished by placing the specimens in racks consisting of frames with galvanized wire for shelves. The velocity of the air over the rack in each room was adjusted to be as nearly the same as possible. The specimens were maintained in random order at all times.

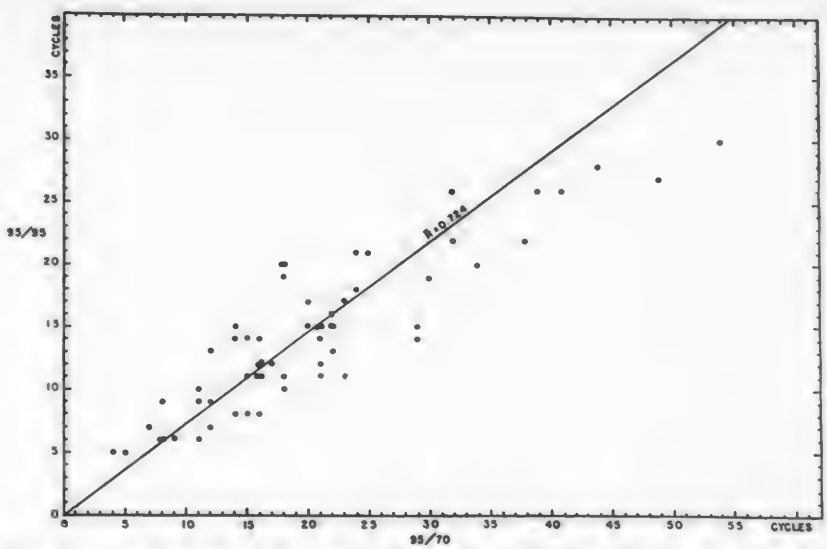

Fig. 2.—Basic data, plotted on rectangular coordinates, of the paired edges comparing the 95° F. soak/95° F. dry treatment with the 95° F. soak/70° F. dry treatment.

Examination for delamination at the end of each cycle was also randomized between treatments.

As the experiment was carried out, it quickly became evident that a very considerable temperature effect existed. None of the specimens subjected to the 95° soak—95° dry temperatures survived more than 30 cycles. However, it was necessary to continue the cycles in the remaining treatments to 60 cycles before there were sufficient data in all treatments to warrant a precise analysis.

In each of the four treatment comparisons, examination of the relationship between the two members of each pair indicated a constant ratio of the more severe treatment to the less severe treatment. The relative severity of the treatments became known as the experiment progressed, with increased temperature being more severe in soaking than in drying and exerting the greatest influence when both soaking and drying temperatures were increased.

Fig. 2 is a plot on rectangular coordinates of the pairs which compared the 95 soak/95 dry treatment to the 95 soak/70 dry treatment. The rather wide dispersion of the points illustrates the variability of the data. However, a constant ratio is indicated but when the ratios of a given comparison were plotted in a frequency histogram, the distribution was skewed toward zero. This might have been expected since

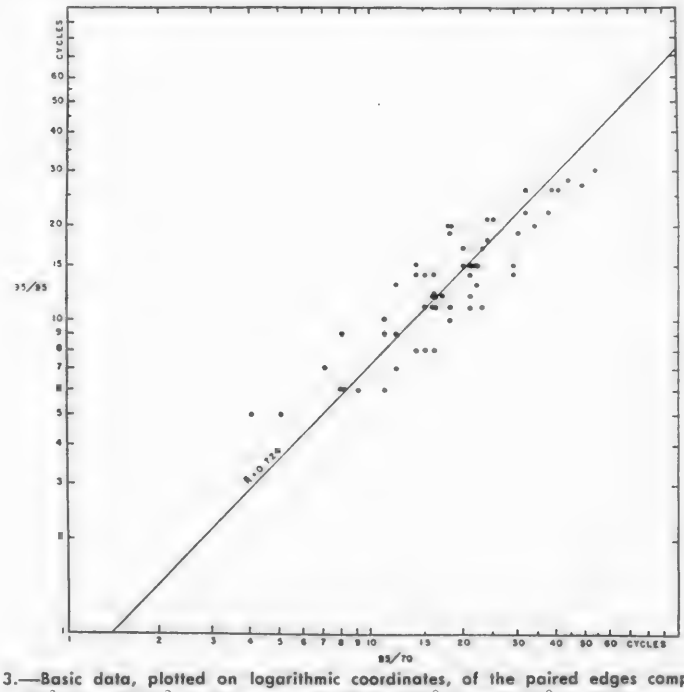

Fig. 3.—Basic data, plotted on logarithmic coordinates, of the paired edges comparing the 95° F. soak/95° F. dry treatment with the 95° F. soak/70° F. dry treatment.

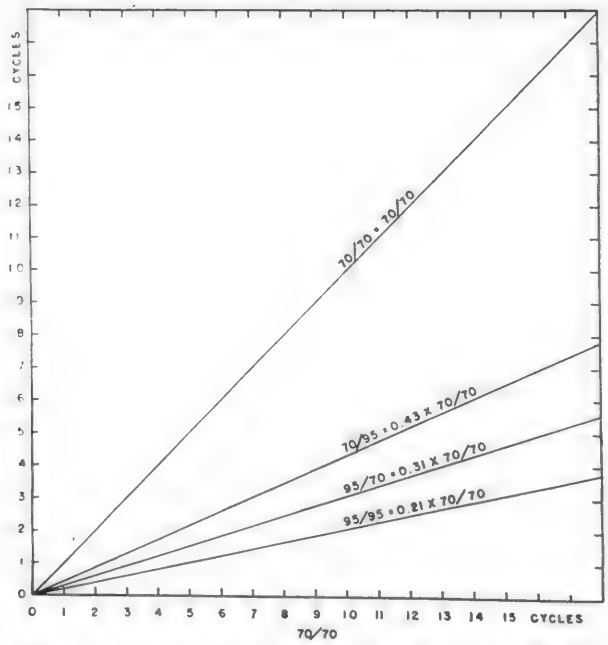

Fig. 4.—Summary graph showing the effect of increasing the drying temperature, the soaking temperature, and both the soaking and drying temperatures from 70° F. to 95° F.

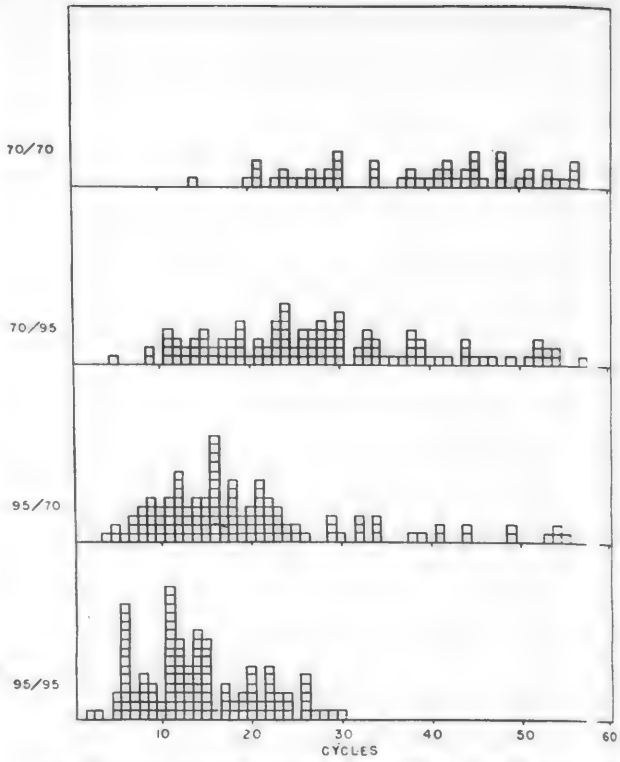

Fig. 5.—Frequency histograms of the number of cycles successfully completed by the specimen edges in each cyclic exposure treatment.

the ratios could not have values less than zero but theoretically could vary to any value above zero. A symmetrical distribution which closely approximated the normal curve was obtained by taking the logarithms of the ratios and plotting them. The mean log was then determined and the antilog gave the median ratio in each of the four treatment comparisons.

Fig. 3, in which the pairs comparing 95 soak/95 dry to 95 soak/70 dry are plotted on log coordinates, clearly illustrates the existence of a constant ratio between the number of cycles completed at each of the two treatments. Table 1 shows the temperature effect in this comparison as well as the other three direct comparisons. The comparison between 95 soak/95 dry and 70 soak/70 dry was obtained by simple algebra through the fact that each is compared directly to both 70 soak/95 dry and 95 soak/70 dry. Thus two independent estimates, 0.197 and 0.223, of the ratio between the high and low temperature effects are available. Their close agreement supports the accuracy of the data. Pooling these two estimates gave 0.210 as the best estimate of the ratio between the two treatments.

In Fig. 4, the relationships between the different treatments are shown.

Table 1.—EFFECT OF TEMPERATURE

Treatment Comparison		R = Median Ratio of	99% Confidence Limits on R	
y	x	y/x	Upper	Lower
70/95	70/70	0.434	0.531	0.354
95/70	70/70	0.308	0.382	0.248
95/95	95/70	0.724	0.786	0.667
95/95	70/95	0.453	0.504	0.408
95/95	70/70	0.210	0.183	0.240

From this graph it may be seen that a specimen which completes 10 cycles at 70/70 would be expected to complete approximately four cycles if the drying temperature were increased to 95°, three cycles if the soaking temperature were increased, and only two cycles if both the soaking and drying temperatures were increased to 95°.

In this experiment the use of paired data was invaluable in obtaining a precise measurement of the relationship between treatments, for it enabled the temperature effect to be calculated without the necessity of continuing the cycles until all specimens had failed. It was also very useful in reducing the high variability that must be contended with in experiments of this type, as is illustrated by the fact that if the paired edges had been six inches apart instead of only 3/16 inches, the results would have been approximately 65% more variable as determined by comparing their respective deviations. However, a clear understanding of the temperature effect may be obtained from the frequency histograms (Fig. 5) of the specimens subjected to each of the four treatments. The median (i.e. the number of cycles below which 50% of the test data lie) is approximately the following for each distribution:

95/95—12½
95/70—16¼
70/95—27
70/70—beyond 60 cycles (66)

It may be noted that the distributions become much more spread out with increasing severity. The 95/95 distribution starts at two cycles and is complete at 30 cycles. The 70/70 distribution starts at 14 cycles with one isolated failure but becomes more definite at 20 cycles. Yet it probably would extend to the vicinity of 150 cycles since specimens at 70/70 will complete approximately five times as many cycles as they will at 95/95.

This greater spread of the 70/70 treatment is largely the result of the greater sensitivity of the less severe treatment. This increased sensitivity is due to the fact that each cycle causes less deterioration. Considered from the viewpoint that there is only so much strength in a given glue line, the less severe treatment reduces this strength by a smaller amount per cycle than does the more severe treatment. Since the number of cycles the specimen will complete at 95/95 is approximately one-fifth the number it will complete at 70/70, a range of quality from 15 to 20 cycles at 70/70 is represented by a range of 3 to 4 cycles at 95/95.

The advantages of a high degree of sensitivity are doubtful in a test that is primarily used in acceptance sampling and quality control work. Such a test must certainly be sensitive enough to measure large variations in quality between panels, but there seems to be

little advantage in also measuring variation within a panel to such an extreme degree, and that seems to be what is accomplished in the cyclic exposure test at 70/70.

The most serious obstacle encountered in making the cyclic exposure test so sensitive is the length of time involved. In reference to the panels tested in this experiment, it would require more than 60 days to determine the point at which half of the specimens had failed, while only 12½ days were required to determine this point at 95/95. For the purpose of obtaining a reasonably accurate estimate of the quality of the plywood produced by a plant, it appears that the more severe test may prove very useful. For example, suppose that a plant is willing to conduct cyclic exposures on each specimen for no more than 10 days. In this period, 25% of the specimens from the panels in this investigation failed when subjected to the 95/95 treatment while there were no failures at the 70/70 level. Thus the more severe treatment may furnish a reasonably accurate estimate of the average quality. With the less severe treatment, there could only be an estimate of the minimum average quality, providing that something was known of the type of distribution the specimens would be expected to follow, but there would be no reasonable estimate of the maximum average quality.

There are disadvantages to the cold soak for delamination type of test, one of the most important of which is the great length of time required to obtain an estimate of the average quality. It also possesses some very real advantages. Principal among these is the fact that the wood itself provides the mechanical force necessary for failure. Thicker plies require glue lines of greater strength to bond them. Some woods exert greater forces with swelling that do other woods. But in this type of test such factors are automatically compensated for, and where product quality is the aim of the test, the cold soak for delamination type of test is a simple and reliable method of evaluation.

Investigating Rotary Veneer Cutting with the Aid of a Tension Test[1,2]

EERO KIVIMAA

Research Associate, Forest Products Laboratory,[3] Forest Service, U. S. Department of Agriculture

Describes method used in making investigations of rotary veneer cutting at the State Institute for Technical Research in Finland. In these investigations, the tensile strength of the veneer perpendicular to the grain, determined by means of a tension test, has been adopted as the standard of veneer quality. Additional tests along similar lines at the U. S. Forest Products Laboratory are described. By using the tension test to evaluate veneer quality, a clearer picture of the influence of nosebar pressure on the quality of lathe-cut veneer has been obtained.

Introduction

AVAILABLE INFORMATION about the quality of rotary-cut veneer is based primarily upon long practical experience and certain laboratory investigations (2).[4] Yet this information is very incomplete, and it is not yet possible in every case to specify accurately the conditions under which veneer of the highest possible quality can be produced.

One reason is that the quality of the veneer produced on the lathe is simultaneously affected by a number of factors, such as characteristics of the wood itself, preparatory treatment, equipment used, and cutting conditions. Cutting conditions include the thickness of the veneer, the cutting diameter, the cutting speed, and the pressure applied by the nosebar as determined by the distance between the knife and the nosebar.

Investigations in this field have been hampered by the absence of an accurate method for determining the quality of the veneer. Without a fixed method of measuring veneer quality, accurate investigations aimed at improving such quality cannot be made readily. Thus, the development of an accurate method for determining the quality of veneer is fundamental to the conduct of veneer-cutting investigations.

In trying to find a solution to this problem, the author previously conducted studies in Finland and obtained good results by measuring the tensile strength of the veneer across the grain. A brief description of this earlier work follows.

Review of Investigations in Finland

As a basis for measuring the quality of rotary-cut veneer, a tension test in the cutting direction, that is, perpendicular to the grain, was applied. In measuring the tensile strength, it was possible to employ a standard materials testing machine designed for testing paper. The sensitivity of the machine was found to be satisfactory for testing veneer strips 1.5 centimeters (0.59 inch) wide. The ultimate strength obtained in the tension test was divided by the cross sectional area of the test specimen (width times actual thickness), so that the results *(f)* were expressed in terms of kilogram/ sq. centimeter. Because of the small size of the test samples and the variable nature of the veneer, one might expect a very great variability in the results. As a whole, however, the results were better than expected.

In veneer-cutting tests on Finnish birch, the tensile test method was found to have the following advantages:

1. The test results are not based on estimates but are expressed numerically. Consequently they can be shown graphically for purposes of analysis.
2. Test specimens may be selected from different points in the veneer, and the tension test itself can be rapidly and easily made.

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[1] Presented at Session XIV, Veneer and Plywood, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] The author wishes to express his appreciation to Dr. H. O. Fleischer for many valuable discussions concerning rotary veneer cutting and the tests described here, as well as for providing an opportunity to carry out this investigation at the U. S. Forest Products Laboratory.

[3] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[4] Numbers in parentheses refer to literature cited.

The Author: Eero Kivimaa, who has been on a scholarship in the United States in 1955–56, is a research engineer in the State Institute for Technical Research, Helsinki, and lecturer in Finland's Institute of Technology. He holds M. S. and Sc. D. degrees from the Institute of Technology.

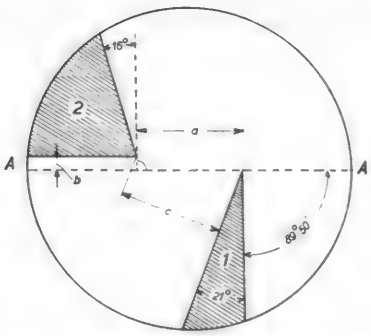

Fig. 1.—Setup used in the cutting test. Knife (1), nosebar (2), horizontal opening (a), vertical opening (b), distance between knife and nosebar (c), and plane going through the axis of the lathe spindles (A–A).

3. The test was found to be very sensitive. It revealed even small variations in the quality of the veneer, especially variations dependent upon knife or lathe checks on the loose side of the veneer. On the other hand, the variability of the strength values was relatively small, so that 3 to 5 test specimens were generally sufficient to obtain a representative mean value at each point of observation.

4. The results of the tension tests have correlated well with results obtained from other methods of estimating veneer quality.

5. From the value obtained in the tension test, one can estimate directly how closely the quality of the veneer approaches that of a clear "ideal veneer" specimen. The tensile strength of "ideal veneer" (f_i) is assumed to be equal to the tensile strength perpendicular to the grain of normal wood not subjected to the veneer-cutting process.

To obtain a fair comparison between the veneer and the normal wood specimen, it is necessary that the value f_i be determined from a sufficient number of test specimens prepared from the same bolts used for the veneer-cutting tests. The size of these test specimens should preferably be the same as that of the veneer specimens themselves. The specimens representing ideal veneer can be made by sawing and planing. Tensile strength values given in handbooks, which are usually obtained from tests on entirely different specimens, are not suitable for comparison.

Because of the relatively small size of the samples required for the tensile test, it was possible to make veneer-cutting tests on short, cylindrical sections, about 2 inches long, instead of on full-size veneer bolts. These disks were fastened to only one spindle of the lathe by a steel bolt passing through the disk. By using such short sections, it is possible to obtain representative material for the tensile tests from a relatively small amount of well selected and matched material of medium quality. This saving of material is important in laboratory investigations.

By making rotary-cutting investigations on small samples under closely controlled laboratory conditions, it was possible to study the effect of one factor at a time, while keeping all other variable factors constant. The significance of a single variable can be studied over a very wide range of conditions, so that a clear picture of its significance can be obtained. Conclusions arrived at in such laboratory tests can then be checked on full-length material in large lathes.

Although tension tests have been carried out primarily on green veneer specimens, the test method can also be applied to dry veneer.

Some of the investigations in which this method was used have been described in a published report on the sharpening of lathe knives (5). This study was made to investigate observations made in cutting-force investigations (4). It was observed that if the lip angle or the sharpening angle of the knife is very small, it can easily become smaller than the so-called "critical lip angle." As a result, the cutting edge may show microscopic fractures which cause deterioration of the cut surface of the wood. Such minute fractures often occur in the veneer knife too, especially when knotty timber is cut. These cutting-edge fractures can be prevented if a bevel, 0.004 to 0.008 inch wide, is honed on the knife edge after machine grinding. The honing is done by hand, and a suitable supporting fixture for the hone is used. It may be done on either side or on both sides of the cutting edge, so that the final lip angle at the cutting edge is about 27 degrees.

The investigation referred to here showed that scratches on the veneer surface can be prevented by such microsharpening, which can be carried out in a few minutes without any lowering of the strength of the veneer. The investigation also indicated the great importance of an accurate lathe set-up, especially with respect to nosebar pressure.

Tests at the U. S. Forest Products Laboratory

The work described above was continued at the U. S. Forest Products Laboratory, where the available equipment offered good possibilities for further demonstrating the suitability of the test method for rotary veneer-cutting tests. For purposes of this demonstration, it was decided to investigate the variation in the quality of the veneer cut with various nosebar pressures. Yellow birch veneer, 1/8 inch thick, was cut from bolts heated for 45 hours in water at 160° F. The log chosen for this purpose was of good quality and about 22 inches in diameter. The average width of the growth ring was about 1/10 inch, the average moisture content was about 80 per cent, and the specific gravity was 0.56, based upon dry weight and green volume. Two bolts, each 42 inches long, were cut from the log, and a 20-inch length from between the 2 bolts was used to prepare "ideal veneer" (f_i) test specimens by sawing and planing.

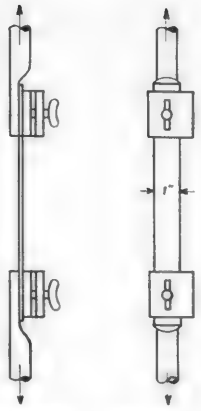

Fig. 2.—Specimen in the grips of the tension test machine.

The terms used in describing the lathe set-up are illustrated in Fig. 1, where *A–A* refers to the plane going through the axis of the lathe spindles. The knife was freshly ground and honed, and the nosebar was fairly sharp. The vertical opening between the knife edge and the nosebar edge, *b*, was 0.015 inch in the test. The lathe was operated at a speed of about 20 revolutions per minute, and the test material was cut from the outer portions of the bolts to a diameter of about 13 inches.

The variable to be investigated, nosebar pressure, is expressed by the symbol *p*, so that

$$p = \frac{(t_h - a) \times 100}{t_h}$$

where *a* is the horizontal opening, and t_h is the nominal thickness of the veneer. In the cutting tests, the horizontal opening between the knife edge and the nosebar edge tapered from one end to the other, so that various values of *p* were obtained. At 1 point near the open end, the horizontal opening *a* was equal to t_h or .125 inch (Fig. 1). This corresponded to a value of $p = 0$ per cent. At a distance of 36 inches from the open end, the horizontal opening was 0.0913 inch, corresponding to a value of $p = 27$ per cent. The change in nose-

b. opening, p, thus amounted to 3 per cent in each interval of 4 inches.

A strip of veneer, 5 inches wide across the grain, was cut into tensile test specimens, 1 inch parallel and 5 inches perpendicular to the grain. Fig. 2 shows the test specimen in the grips of the tensile testing machine. The test results were expressed by the term f, in pounds per square inch of actual cross sectional area.

By cutting test specimens from this veneer strip, veneer was obtained that had been cut under various nosebar pressures of $p = 0$, $p = 3$ per cent, $p = 6$ per cent, and so on up to $p = 27$ per cent. A total of 40 test specimens were cut from a single strip of veneer. Groups of 4 adjacent specimens were considered to be in a single class, 2 on each side of the point that accurately represented the p value. Test strips were taken at three different locations from the veneer produced from each bolt. For each value of p, therefore, 24 specimens were tested, and the mean strength was calculated from these test values.

To eliminate any possible slight variation in the quality of the wood longitudinally in the log, the two bolts were turned end for end when they were mounted in the lathe. In this way, one bolt was mounted with its butt end at the open end of the nosebar, and the other with its top end. After the veneer cutting started in each bolt, more than 10 revolutions of veneer were cut before the first set of test specimens was selected. This was found necessary in preliminary tests, because the high nosebar pressure applied at one end caused the veneer to be too thin during the early revolutions, and complete equilibrium was not reached until after a number of revolutions. After the test material had been cut, some further revolutions were made with the nosebar withdrawn entirely and tension test specimens were also taken from this veneer.

The lathe setup described above was made with the utmost care. The Forest Products Laboratory horizontal opening indicator (3) was used to measure the horizontal opening. To determine whether the horizontal opening remained constant during cutting, dial gage indicators were installed at both ends of the knife carriage to measure any movement between the knife beam and the nosebar beam. When the setup was ready, these indicators were set at zero. After the veneer cutting had begun and the nosebar beam had been forced slightly backward due to the forces acting upon it, an additional adjustment was made so that the indicators again measured zero. This adjustment was necessary for accurate tests, because some play may occur even in the best lathes. Since wear occurring during the life of the lathe can be considerable, especially in old machines, the actual nosebar pressure may often be less than intended.

The above method of expressing the nosebar pressure in terms of the horizontal and vertical opening is standard in veneer-cutting studies. Another method of expressing the nosebar pressure is more appropriate in principle. It is based on the distance, c, between the nosebar and the surface of the knife, measured perpendicular to this surface (Fig. 1). If the latter method had been used, the nosebar pressures corresponding to p values of 0 per cent to 27 per cent would have been 2 per cent to 28 per cent. At the open end, where the horizontal opening $a = t_h$, or 0.125 inch, the distance c is only 0.122 inch or about 2 per cent smaller than the nominal veneer thickness.

Results

The results of the tests described above are shown in graphic form in Fig. 3, where the tensile strength of the veneer perpendicular to the grain (f) is shown as a function of nosebar pressure p. The tensile strength of an ideal veneer (f_1) or of wood not injured in the veneer-cutting process is shown by the horizontal line at the top of the graph. The tensile strength of veneer cut with the nosebar withdrawn is shown at point A. To the right is a scale showing the per cent of tensile strength (f) in terms of f_1. The upper curve in Fig. 3 shows the variation in thickness of the veneer produced (Δt), as a function of p, expressed in per cent of the nominal thickness of the veneer, $t_h = 0.125$ inch.

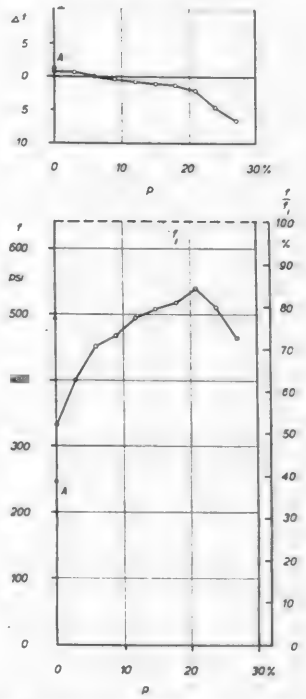

Fig. 3.—Tensile strength (f) of green veneer perpendicular to the grain as a function of nosebar pressure (p). Symbol f_1 represents corersponding strength of normal matched wood samples, and point A represents veneer cut without use of nosebar. The upper figure illustrates the change of veneer thickness Δt in percent of nominal thickness $t_n = 1/8$ inch. The wood species was yellow birch and the cutting temperature was 160° F.

The tensile strength curve of the veneer goes up rather rapidly with increasing pressure (p). The f value corresponding to a value of $p = 0$ is relatively high compared to point A, which represents veneer cut without the nosebar. This indicates that the veneer receives considerable support from the nosebar, because the distance between the knife and the edge of the nosebar is less than the nominal thickness of the veneer (Fig. 1).

The most surprising thing about the strength curve is the very distinct maximum value reached at the point $p = 21$ per cent, although the quality of the veneer is almost as high at $p = 12$ per cent. The curve declines steeply after the maximum point has been passed, and the apparent reasons are damage to the veneer caused by excessive pressure and permanent deformations in the fine structure of the wood. This observation is also supported by the corresponding change in the slope of the curve representing Δt. This curve shows that a minor decrease in thickness of the veneer occurs as moderate nosebar pressures are applied. This thinning action continues to the point of maximum tensile strength, where the veneer is about 2 per cent thinner than its nominal thickness. At pressures less than those that give maximum strength, the deformations occurring in veneer cutting are therefore mainly within the elastic limit. This limit, however, is definitely, passed at the point $p = 21$ per cent.

The shape and high maximum value (about 83 per cent of the strength of ideal veneer) of the strength curve indicate that other factors that may affect the quality of the veneer, such as the heating temperature, apparently were suitable in this case for the cutting of good yellow birch veneer. This is particularly impressive when the relatively great thickness of 1/8 inch is considered. The exact optimum values for the various factors can, of course, only be determined by future separate investigations.

The relatively high strength values obtained in these tests underline the fact that yellow birch is a very good wood for rotary cutting. Species that are more brittle, more easily overcompressed, or more easily damaged in cutting probably cannot be cut to this thickness and to such a relatively high tensile strength value so easily. It is also possible that some yellow birch logs cannot be cut into such uniformly good veneer as that produced from the select log used in these tests.

Some exploratory tests were made before the test described here. These tests are not described here in detail. Using the varying nosebar pressure method described above, yellow birch veneer was cut into 3 thicknesses: 1/8, 1/16, and 1/32 inch. Analysis of the results showed that a definite peak in the strength curve was attained (Fig. 3). With thinner veneers, however, this maximum point was reached at lower p values. This result also conforms to that obtained in earlier work with a somewhat different setup (5). In this earlier work, the optimum pressure was 17.5 per cent, when 1/16-inch-thick veneer was cut from unheated Finnish birch. Other preliminary work indicated that a vertical opening (b) of 0.015 inch was more advantageous for cutting 1/8-inch yellow birch veneer than an opening of 0.028 inch, which was used in another preliminary test. The tension test was also found suitable for measuring the quality of veneer from other species, such as sweetgum and Douglas-fir.

Discussion

It is obvious that the tension test method can be used to evaluate the quality of veneer cut on the slicer, since such veneer may also have knife checks as does rotary-cut veneer. It may be possible to employ the test for continuous quality control of veneer cutting under factory conditions. The test may also be appropriate for determining the tensile strength of dry veneer. This would be useful in selecting veneer for gluing or surface treatment studies of plywood, particularly studies in which the glue joint strength or the surface treatment may be affected by the quality of the veneer.

No studies have yet been made of the significance of the size of test specimens used for the tension test. The dimensions used to date, 1.5 centimeters (0.59 inch) and 1 inch, apparently have both been satisfactory.

In some cases, it may be possible to roughly evaluate the quality of the veneer by eye or by measurement of its thickness. Corrugated veneer surfaces caused by incorrect knife angle are readily seen by eye (2). The smoothness of the veneer surface may also be measured by some other suitable method (6).

Time was too short to allow a thorough comparison of the tension test with an earlier scarfing test method used to evaluate the quality of veneer.[5] Fig. 4 shows samples of yellow birch specimens that have been scarf cut, with a slope of 1 to 5. Before scarfing, a black dye in alcohol suspension was applied to both sides of the dry veneer. Specimen A shows clear knife checks in veneer cut when nosebar pressure, $p = 0$ per cent. The next specimen shows maximum strength veneer cut with an optimum nosebar pressure of $p = 21$ per cent. The third specimen shows over-compressed veneer ($p = 27$ per cent)

The knife checks visible on the loose side (exposed at upper edge of the photo) of sample A cannot be observed in samples B and C which were cut at higher nosebar pressures. In the over-compressed sample C, however, the black stain appears to have penetrated the wood structure on both sides of the veneer. This fact supports the assumption that the wood structure has been injured as a result of over-compression. Additional scarfing tests on veneer cut with other values of p indicated that it is possible to use this method to follow the changes in the quality of the veneer. However, the changes cannot be followed so clearly and distinctly as with the tension test.

The scarfing test will probably work better on veneer with relatively clear lathe checks throughout, including so-called "tight" veneer. This is illustrated in recent studies by Batey (1), in which the scarfing method was used to evaluate Douglas-fir veneers of different cutting qualities.

The scarfing test has the advantage of providing a very clear picture of the depth of lathe checks and their nature. Preparation of the scarfed specimens is more difficult than preparation of tension test specimens, and the evaluation of the scarfed veneer involves a visual estimate. There is also the possibility that the penetration of the dye may depend to some extent upon the manner of spreading and

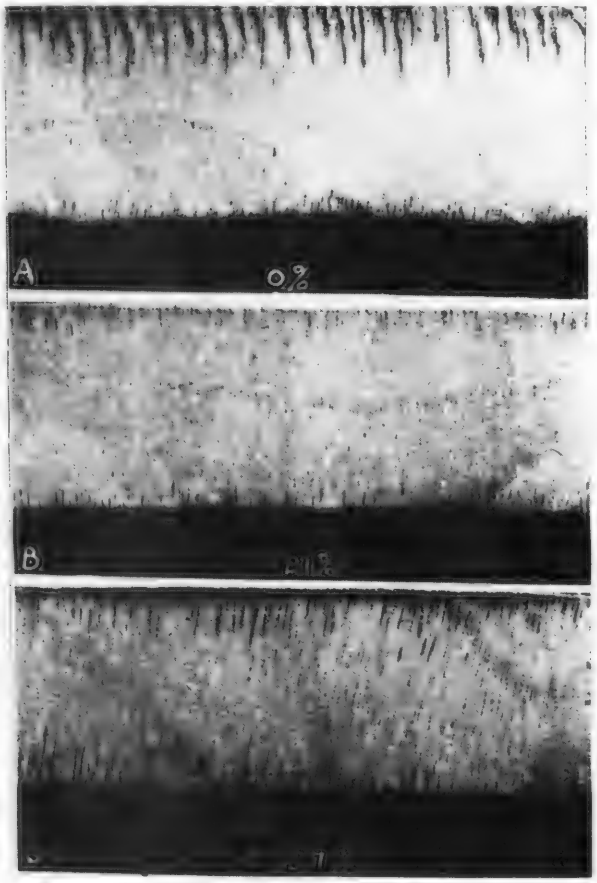

Fig. 4.—Three scarfed (1 to 5) sections of veneer corresponding to nosebar pressures (p) = 0 per cent, 21 per cent, and 27 per cent in Fig. 3. Before cutting, black dye was applied to both sides of dry veneer. In the illustration, the under side of veneer is the "loose" side.

[5] For the instructions concerning the scarfing test and for the valuable assistance obtained in this investigation, the author is indebted to John F. Lutz, Technologist, U. S. Forest Products Laboratory.

the amount of dye applied. Some stain appears to penetrate undamaged wood, and in thin veneers, the wood may be colored throughout. The tension test on the other hand can be used equally well with thin veneers or thick veneers.

One may conclude, therefore, that the tension test is likely to have general applicability for measuring the quality of veneer cutting, whereas valuable additional knowledge regarding the type of defect may be obtained in some cases by use of the scarfing test.

Summary

The quality of veneer produced in the rotary-cutting process is greatly affected by many factors simultaneously at work during the cutting operation. The detailed effect of each of these factors on the quality of the veneer is not yet known. Accurate investigations aimed at improving the cutting quality of veneer presupposes precise methods of measurement during the cutting operation and evaluating the quality of the veneer produced.

The tensile strength of green veneer perpendicular to the grain can be used as a suitable standard for measuring the quality of the veneer. An easily made tension test can be applied to simple veneer specimens. The test seems to apply to veneer of any thickness and species. The test is not dependent upon estimate. However, quantitative values are obtained that reflect not only the depth of knife checks but wood damage caused by nosebar over-compression. The test results have further value since they indicate comparative values in relation to the tensile strength of an ideal veneer of equal thickness, produced by sawing and planing. In the test described here, considerable information has been obtained regarding the effect of varying nosebar pressure on the quality of rotary-cut veneer.

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Highlights of the Central States Forests[1]

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Discusses forest resources of six central states, including volume, type, size classes, location, and availability. Timber growth exceeds drain in this area, but the quality is not adequate to serve existing needs. The quality of the stands can be improved, however, and there is room for industries that can utilize lower grades of hardwoods.

SIX STATES SERVED by the Central States Forest Experiment Station comprise the area covered in this paper. They are: Illinois, Indiana, Iowa, Kentucky, Missouri, and Ohio.

At the time of settlement forests covered 64 per cent of the land area in these states. Now forests cover 22 per cent of this land area. At the turn of the century this region was producing 4 to 5 billion board feet of lumber annually. Now it is producing less than 2 billion board feet of lumber annually. Lumber production started to decline in the Central States after the turn of the century, recovered briefly during the first World War, then began to decline again and reached its lowest ebb during the depression years.

Many farms lost during the depression were never reclaimed—at least not totally—and as a result thousands of acres have grown back into timber during the last 20 years. With the coming of the second World War, lumber production increased in the Central States, but forests of this region had recovered well enough during the lean years so that present industries do not require all of the current growth. In fact it appears that there is a good opportunity to expand wood-using industries in this region and through them to practice better forestry.

These are not static forests in the Central States as might be found in some virgin forests of the West. These are growing forests—the area, volume, quality, annual growth—all are changing each year. For this reason present figures may not be the same as may be reported six months or a year from now. Also, the data collected in Iowa has not been completely analyzed and preliminary estimates for Iowa have been incorporated to arrive at regional averages.

There are now about 42½ million acres of forest land in the Central States (about half as much forest land as cropland). Some worthwhile woodlands are found in nearly every county, but as might be expected, the forest area is largely concentrated in the mountainous areas of Missouri, Kentucky, and the southern portions of Ohio, Indiana, and Illinois. Some counties are still more than 90 per cent forested while some in the original prairie areas are less than 2 per cent forested. Missouri, with 15 million acres, has the most forest area, followed by Kentucky with 11.4 million acres. Iowa has the least forest area (about 3 million acres).

Readily Accessible

Practically all of the forest land in this region is commercially important. That is, nearly all of it will grow sawlog-size timber and all of it is accessible with modern logging equipment. Only about 250,000 acres of public land, mostly in parks and other recreation areas, have been withdrawn from cutting.

Of the forest land in the Central States, 92 per cent is privately owned. The federal government owns a little

[1] Presented at meeting of Ohio Valley Section, FPRS, May 13, 1955, in Louisville, Ky.

The Author: O. K. Hutchison received B.S. degree from Oregon State College in 1939, was employed seasonally by U. S. Forest Service from 1936-1940. He served with U. S. Army topographic mapping unit from 1941-46, has since been employed by Central States Forest Experiment Station on forest survey and economic investigations.

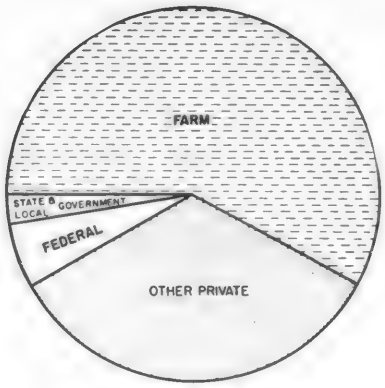

Fig. 1.—Forest land ownership.

less than 6 per cent and state, county, municipal, and other public agencies own the remaining 2 per cent. Most of the federally owned forests are in Missouri and Kentucky, which have the more important national forests of this region.

About 25 million acres of forest land are on farms. From the standpoint of good forest management, much of the farm woodlands are troublesome. These woodlands often are so small that they cannot be handled as a commercial enterprise, although they are suitable for supplying the farm with lumber, posts, poles, and fuelwood. For example, in Indiana the farm woodlands average less than 30 acres per farm. The 14 million acres in other private ownerships are larger and some tracts are well-managed.

The oak-hickory type makes up 68 per cent of the forest area of this region. This type is generally found on the well-drained slopes and ridge tops. While this type includes some of the poorest timber, it also contains some of the best. In this type is found most of the fine white and red oaks, yellow-poplar, and black walnut.

Elm-ash-cottonwood type make up 18 per cent of the forests. This type is found largely along streams and poorly drained bottoms; mostly in Missouri and Illinois. Many fine logs are taken from these stands for container veneer.

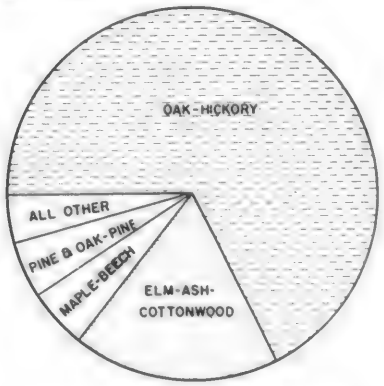

Fig. 2.—Forest area by forest types.

The maple-beech type comprises 5 per cent of the forest area and is found mostly in Kentucky, Ohio, and Indiana. This type contains a lot of over-mature beech for which there wasn't a market until recent years. The sugar maple in this type is tapped for syrup in northeastern Ohio and to some extent in Indiana.

The pine and oak-pine types together comprise only 5 per cent of the forest area. These types are found mostly in Missouri and Kentucky. Most of the pine is shortleaf.

Size Classes

Only 34 per cent of the forest area is classed as sawtimber stands. Sawtimber stands mean stands that have 1500 board feet or more per acre in trees 11 inches in diameter and larger if hardwoods and 9 inches and larger if softwoods. 37 per cent of the area is poletimber, 21 per cent is seedling and sapling stands, and 8 per cent is not stocked with trees of any size.

Forest conditions vary greatly by states, however. For example, in Missouri only 13 per cent of the forest area is classed as sawtimber while in Indiana and Ohio the figure is 50 per cent. There is a difference too in the condition of the several stand classes identified. In general the sawtimber stands have the better stocking followed by poletimber and seedling-sapling stands. The poorly stocked stands are more common in the regions of fenced farm woodlands where livestock raising is important. Allowing livestock to graze hardwood stands can be very destructive to the forest because the livestock kill so many seedlings and saplings needed to perpetuate the stand.

It is not known how much volume was in the original forests but some people believe they may have averaged 10,000 board feet per acre or more. If so, there was about 15 times as much sawtimber as at present. Now there is upwards of 80 billion board feet of sawtimber in the Central States.

Most of the sawtimber volume is in Kentucky. Kentucky has 33 per cent of the total, followed by Ohio with 18 per cent. Ohio has more sawtimber than Missouri although Ohio has only about 1/3 as much forest land as Missouri. Although Missouri has nearly 36 per cent of the forest land, it has only 16 per cent of the sawtimber volume. Illinois and Indiana each have 14 per cent and Iowa has 5 per cent.

The sawtimber volume is not badly scattered. 82 per cent of the volume is in sawtimber stands. The sawtimber is most scattered in Missouri where only 48 per cent of the volume is in sawtimber stands. Ohio and Indiana, on the other hand, have 90 per cent or more of their sawtimber in sawtimber stands.

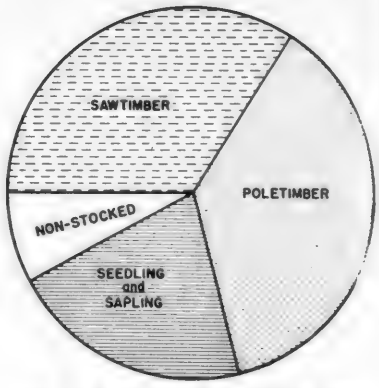

Fig. 3.—Forest area by stand-size class

For the Central States as a whole, the sawtimber area averages 4656 board feet per acre. The states in the region average from 3200 to 5700 board feet per acre. In general, the most heavily stocked stands to be found are in the corn belt areas of Illinois, Indiana, and Ohio where timber demand has not been great and many stands have been cut only lightly if at all in the past 30 years. There are individual stands in any of the Central States where the volume averages 25,000 board feet or more per acre for a few acres.

Hardwoods Predominate

Hardwoods comprise 96 per cent of the volume in the Central States. This is not an important softwood producing region, although the pine volume is increasing due to the amount being planted on old fields and on strip-mined areas, and as a result of natural restocking of the pine producing areas of Missouri, Kentucky, and southern Ohio and Indiana. This region's future in forestry, however, is in growing hardwoods and particularly high-quality hardwoods.

Oaks of several species make up 50 per cent of the hardwood sawtimber volume. This region is well known for its white oak *(Quercus alba)*, which is in demand for barrel staves.

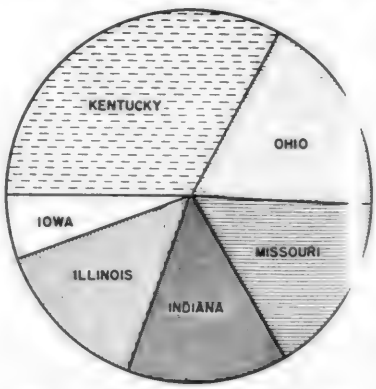

Fig. 4.—Sawtimber distribution by state

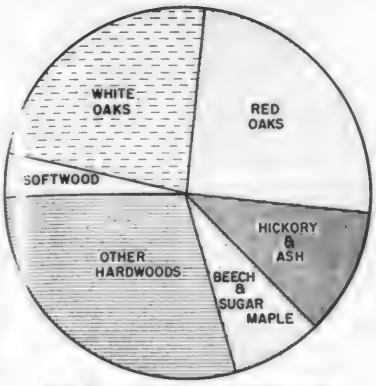

Fig. 5.—Sawtimber distribution by species groups.

veneer, and lumber, and there are about 11 billion board feet of this important tree. Other white oaks account for another 8 billion board feet. High valued species such as yellow-poplar, sugar maple, white ash, cottonwood, and black walnut each account for less than 5 per cent of the volume.

The distribution of these important species varies from one state to another, however. As a result, stave mills concentrated in Missouri get the white oak, veneer buyers in Iowa get the black walnut, and container veneer mills along the Mississippi River get the cottonwood. More than one-third of the yellow-poplar is in the mountains of eastern Kentucky. Kentucky also has most of the beech and hickory, while Ohio has more white ash than any other state of this region.

Importance of Quality

An important characteristic of hardwood timber—one that is too often overlooked—is quality. Though this region has nearly 40 per cent of its sawtimber volume in trees 18 inches and larger, less than 20 per cent of the sawtimber volume is in high quality logs—those that will return 40 per cent or more of their volume in No. 1 common and better lumber. This is an important item considering how much No. 3 common and poorer lumber a sawmill operator must find a market for in order to stay in business.

To avoid this problem as best he can, the sawmill operator cuts only the best trees in the stand. There are exceptions to this, of course. For example, in northeastern Ohio there is a good market for car blocking. This enables the sawmill operator to cut everything—down to about a six-inch diameter limit. However, about 40 per cent of the volume going to sawmills is in high quality logs. Add to this the selective harvesting for veneer, cooperage, and handle stock and it is apparent why one of every 5 or 6 sawtimber trees now in these stands is a cull. The amount of cull trees is increasing because many ways have not been found to economically utilize them or to encourage the owner to cut or girdle them.

Studies of wood utilization have usually been made by questioning the users of wood such as sawmill operators, pulp mills, veneer mills, and so on. It is possible to obtain good information in this manner concerning total production but a breakdown by species, tree size, quality classes, or even state source is sometimes weak. However, it is known that logs and bolts used for veneer, cooperage stock, and handles have to be high quality and that almost all of this has to come from trees that are 16 inches or larger in diameter. Furthermore, studies at sawmill decks have shown that about 40 per cent of the log volume cut into lumber is in high quality logs. In the Central States this adds up to a greater cut of high quality timber than is being grown. For example, in Kentucky the cut of high quality logs exceeded the growth of this class by 47 per cent, though total growth exceeded total cut.

In Ohio it was found that 16 per cent of all timber cut was white oak; other white oaks accounted for another 7 per cent; red and black oaks 23 per cent. This means that 46 per cent of the cut in Ohio is oak, while oak accounts for only 38 per cent of the inventory volume.

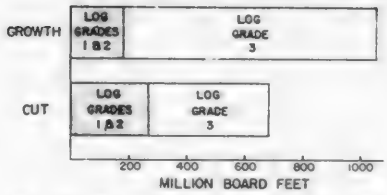

Fig. 7.—Comparison of sawtimber growth with timber cut in Kentucky.

are understocked. However, 80 per cent of the forest area is well enough stocked that the volume will increase rapidly—given nothing more than good protection and good cutting practices. Too much of the growing stock is in the small diameter classes to obtain maximum growth. To obtain maximum growth most of the volume should probably be in the 16- and 18-inch diameter classes rather than in the present 10- and 12-inch classes.

Very little variation in the growth rate of timber has been found in this region. The board-foot growth of sawtimber size trees has averaged close to 3.4 per cent of their volume. There is a little more variation in the growth of trees from poletimber into sawtimber-size, termed ingrowth. The rate of ingrowth has ranged from 1.5 per cent to 3.2 per cent of the sawtimber inventory volume. This variation is almost entirely due to differences in stocking—areas with a lot of poletimber have a higher rate of ingrowth. Adding these two growth parts together, it is found that for the region, total net board-foot growth equals approximately 5 per cent of the inventory volume.

The annual growth of sawtimber in this region is more than 4 billion board feet. In some respects, this growth is good, although it could be greatly increased. This amounts to an average of less than 100 board feet per acre and it is known that 200 to 300 board feet per acre could be obtained with reasonable effort. Growth is good if it is considered this region is growing more than twice the amount being cut. However, of the sawtimber cut, 85 per cent is for lum-

Good Potential

The encouraging part of this picture is that this region has the growing stock that would permit rapidly improving the quality of stands. There are more than 25 billion cubic feet of growing stock in the region (about 580 cubic feet per acre) and 40 per cent of it is in trees below sawtimber size. Another 24 per cent is in small sawtimber (trees in the 12- and 14-inch class).

This region could probably support three to four times as much volume, indicating that in general the stands

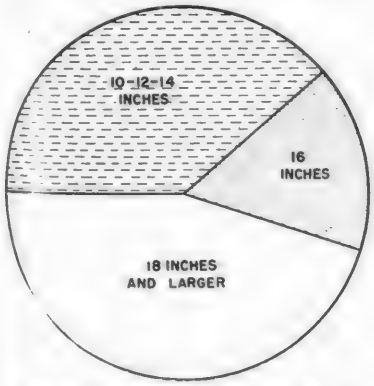

Fig. 6.—Sawtimber distribution by tree diameter.

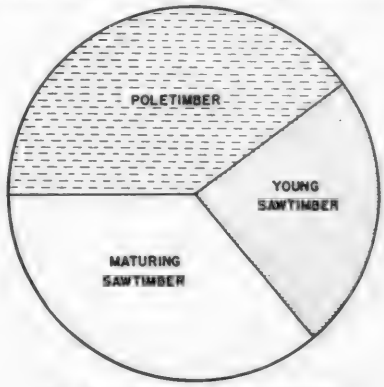

Fig. 8.—Growing stock distribution by size classes.

ber, veneer, and cooperage. Under present utilization practices, high quality logs are needed for these uses, but only 15 to 20 per cent of the growth is high quality.

Industry Needed

The Central States have plenty of wood that is not being used. Industries are needed that will use certain kinds of wood in order that better forestry may be practiced. For example, this region has 65 million cords of sound wood in cull trees (more than 1½ cords per acre). The limbs and upper stems of trees that are harvested each year amount to another 3 or 4 million cords. There are another 1 to 2 million cords available each year in dead trees. Sawmills and other primary plants have a million cords of wood available each year in the form of slabs, edgings, backing boards, cull blanks, and so on.

Total growth exceeds the cut by 2 billion board feet. While there should be a surplus of growth over cut in order to build up the stands, some of this surplus might be used provided the stands are left in better condition to grow after cut. With so much wood available, almost any industry can be encouraged as long as such industry will use low quality wood. This region is not growing enough high quality sawtimber to sustain present needs, yet the Central States can benefit most from its forests by growing high quality hardwoods.

Of course, utilization methods may change. Wood chips are coming more and more into the picture. Great advances have been made in recent years towards the pulping of hardwoods. The industry is learning to fabricate many wood products. Perhaps a product can be fabricated to take the place of fine hardwood veneers, cooperage stock, specialty squares, interior finish and so on. However, it is doubtful if a fabricated product can equal the beauty of natural wood. Thus every effort should be made to improve the quality of timber stands.

Conclusion

To manage forest lands properly, it is essential to know what is available to work with. The Forest Survey in the Central States is giving some knowledge of forests and their condition. The thin sampling employed in these initial surveys, however, does not provide the local information that many timber operators and forest landowners want. Perhaps future inventories can be made more intensive through cooperative efforts of state and industrial organizations.

A number of large forest landowners are interested in continuous inventory procedures. Their needs and those of the Forest Service can be served through mutual effort in some cases. The active support of FPRS and its individual members can help make future forest survey work more intensive and applicable to local working units.

Handbook for Small Sawmill Operators

How to Attain and Maintain Accuracy of Cutting

Part IV. Mill Operation and Trouble Shooting

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and

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Practicing preventive maintenance will lessen the need for trouble shooting in any sawmill. Routine checking of the entire mill setup will improve the quality of lumber sawn. Almost equally important is the accuracy of calculation of thickness to be obtained from a cant or flitch. The aim should be minimizing both mechanical and human errors in operation of the sawmill.

THE FINAL CHECK of the mill installation is the quality of the lumber produced and the behavior of the mill while in operation. Whether lumber is sold to size standards or not, it is good milling practice to check at frequent intervals the dimensions of the lumber being produced (as specified in the Introduction to this Handbook) in order to discover mechanical or equipment troubles that may be developing in the mill. Frequent checking of lumber dimensions enables the operator to quickly ascertain whether log volume is being sacrificed by cutting too full, or lumber volume lost by cutting scant.

The Dog Board as an Aid in Trouble Shooting

The dog board (last board on the carriage to which the carriage dogs are attached) most commonly shows the accumulation of mechanical and human errors that develop in the process of sawing logs. In cases where the log is being sawed on all four faces, these troubles will sometimes show up the second time a sawed face is turned to the saw. The occasional miscut dog board that can be traced to a nonrecurring calculation error or a temporary condition, such as a wood chip wedging the board away from the knee, can be reduced in frequency by personnel training. When miscut dog boards fall into a constant pattern, the operator is warned of equipment troubles that result in poorly sized lumber.

Common inaccuracies that occur in the dog board and possible causes for such miscuts are shown in Figs. 32-35.

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The checks to determine which specific troubles are responsible and the ways of remedying them in most cases should be obvious to anyone who has read the previous three parts of this Handbook.

Miscut Lumber other than the Dog Board as an Aid in Trouble Shooting

Lumber other than the dog board may also indicate faulty conditions in the mill. Some common occurrences illustrative of these conditions are shown in Figs. 36–38.

Summary of Common Causes of Poorly Sized Lumber

Miscut lumber is often traceable to a combination of troubles rather than to a single factor. Following is a summary of the most common causes of poorly sized lumber. As indicated, the remedies for most of them have been covered previously in this Handbook.

1. Improper saw lead. (See Part III "Mill Setup")
2. Saw improperly filed and/or swaged. (See Part II "Saws")
3. Saw operated at incorrect speed for condition of tensioning. (See Part II "Saws")
4. Husk and track not level or out of line. (See Part III "Mill Setup")
5. Guides used to force lead into saw. (See Part III "Mill Setup")
6. Setworks ratchet and pawl worn. (See Part I "Machinery")
7. End play in carriage and/or saw mandrel. (See Part I "Machinery")
8. Insufficient number of headblocks to hold logs securely. (See Part I "Machinery")
9. Logs not dogged securely. (See Part I "Carriage")
10. Inadequate power. (See Part I "Power")
11. Loose guides on husk. (See Part III "Mill Setup")
12. Carelessness in cutting. (See other parts of this section)

Additional troubles frequently show up in the course of operating a sawmill. Heating of the saw is an indication of trouble that requires attention. The manner in which the saw heats is often a clue to the cause of heating as well as the cause of some of the inaccuracies in cutting cited previously.

Causes for Saw Heating on the Rim

1. Too much saw lead into the log. Adjust lead.
2. Saw too stiff, improperly tensioned for the speed of operation. Needs opening in the body.
3. Cutting points of saw teeth not wide enough to give proper clearance. Install wider teeth or swage to obtain greater clearance.

PREFACE

The Handbook for Small Sawmill Operators was prepared by the Logging and Milling Committee of FPRS at the request of Sectional Committee B–66 of the American Society of Mechanical Engineers.

The material has been divided into six parts being published serially in the Forest Products Journal. It will be available later as a separate bulletin from the Standards Department of ASME, 29 West 39th St., New York 18, N. Y.

Publication of this Handbook by FPRS and ASME is not to be construed as establishing any new dimensional standards for lumber. Such standards are promulgated by the American Lumber Standards Committee for softwoods and by the National Hardwood Lumber Association for hardwoods. It is designed specifically to show the small sawmill operator how he can produce lumber to those standards more economically and most efficiently.

Acknowledgment is due many people, representing the several groups interested in the small sawmill business in various ways, for the constructive help and advice given in this handbook compilation. The Committee is very grateful to all those who helped so generously.

FRED C. SIMMONS, *Chairman*
FPRS Logging and Milling Committee

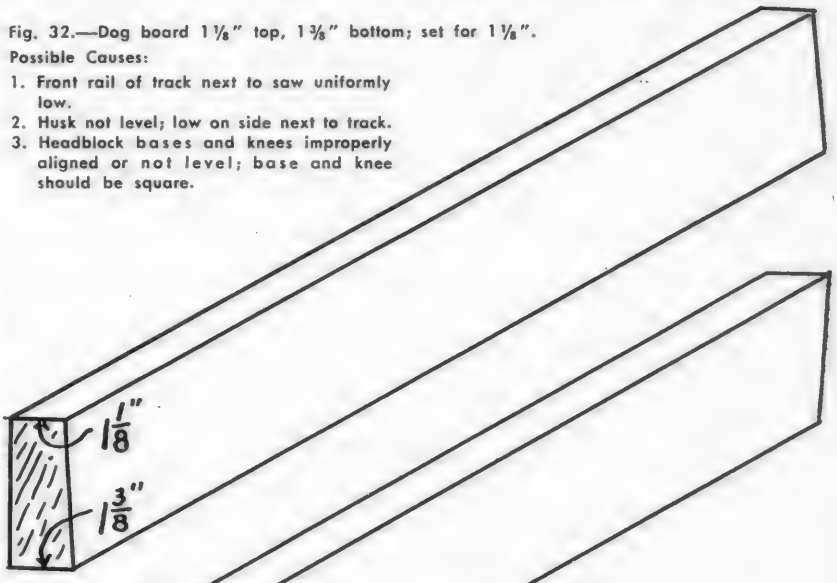


Fig. 32.—Dog board 1⅛" top, 1⅜" bottom; set for 1⅛".

Possible Causes:
1. Front rail of track next to saw uniformly low.
2. Husk not level; low on side next to track.
3. Headblock bases and knees improperly aligned or not level; base and knee should be square.

Fig. 33.—Dog board 1⅜" top, 1⅛" bottom, set for 1⅛".

Possible Causes:
1. Rear rail of track uniformly low.
2. Husk not level; low on pulley side.
3. Headblock bases and knees improperly aligned or not level; base and knee should be square.

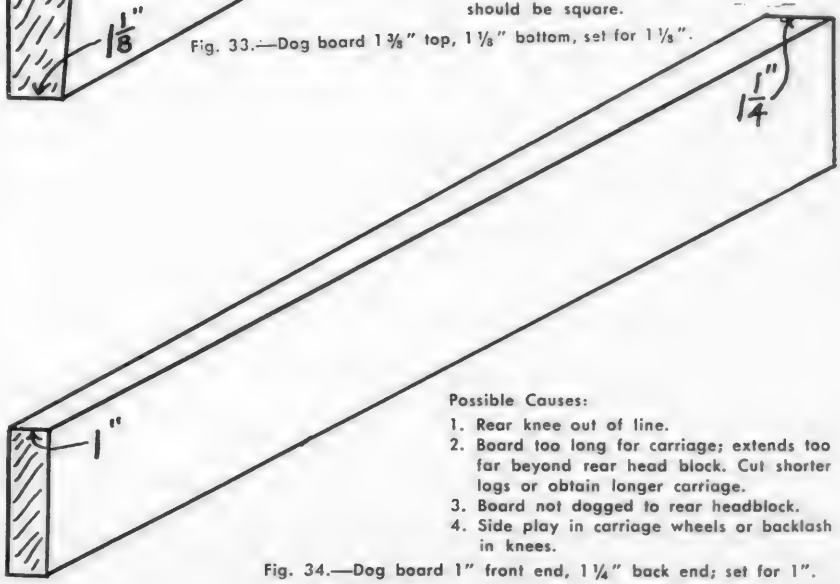


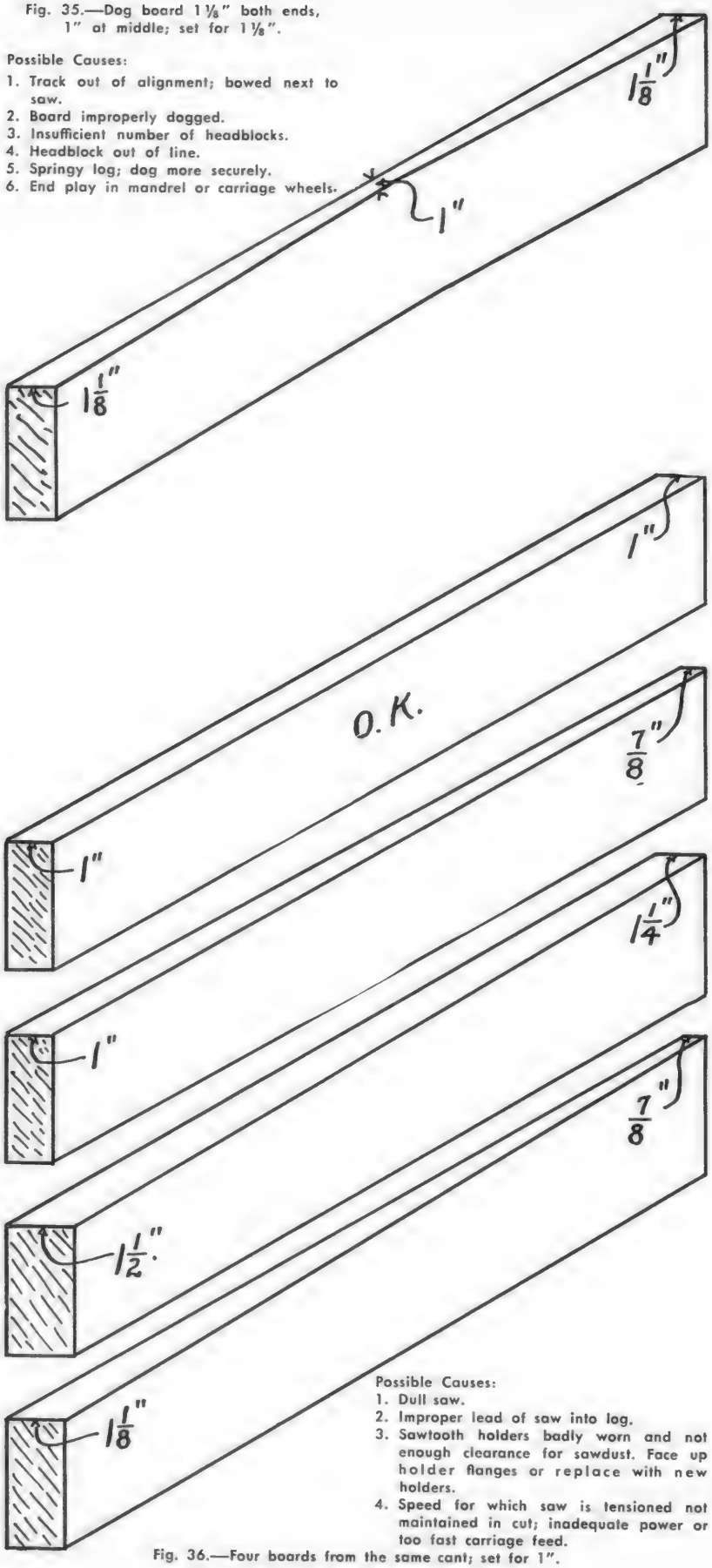
Fig. 34.—Dog board 1" front end, 1¼" back end; set for 1".

Possible Causes:
1. Rear knee out of line.
2. Board too long for carriage; extends too far beyond rear head block. Cut shorter logs or obtain longer carriage.
3. Board not dogged to rear headblock.
4. Side play in carriage wheels or backlash in knees.

Fig. 35.—Dog board 1⅛" both ends, 1" at middle; set for 1⅛".

Possible Causes:

1. Track out of alignment; bowed next to saw.
2. Board improperly dogged.
3. Insufficient number of headblocks.
4. Headblock out of line.
5. Springy log; dog more securely.
6. End play in mandrel or carriage wheels.



Possible Causes:

1. Dull saw.
2. Improper lead of saw into log.
3. Sawtooth holders badly worn and not enough clearance for sawdust. Face up holder flanges or replace with new holders.
4. Speed for which saw is tensioned not maintained in cut; inadequate power or too fast carriage feed.

Fig. 36.—Four boards from the same cant; set for 1".

4. Feed too rapid for the number of teeth (gullet capacity) in the saw. Reduce feed or install different saw.
5. Saw sprung or twisted. Needs hammering.
6. Teeth not properly sharpened. Check for sharpness and angles; resharpen.
7. Guide pins too close.
8. Backs of teeth set too high. This often results from filing tops of teeth. May require new teeth.
9. Accumulation of gum or resin on teeth. This can be removed with kerosene or cleaning fluid.

Causes for Saw Heating at the Center

1. Faulty bearings binding on mandrel transfer heat to saw. Adjust and lubricate bearings, replace if necessary.
2. Saw open in the body, not properly tensioned for the speed of operation. Needs hammering.
3. Not enough saw lead into the log.
4. Saw sprung. Needs hammering.
5. Saw speed not fast enough to expand the rim. Increase speed or retension saw.
6. Sprung mandrel. Factory straightening job or new mandrel needed.

Miscalculation

Mathematical miscalculation in breaking down the log on the headrig is a common source of inaccurately sized lumber that is completely independent of problems of saw maintenance and machinery operation. Miscuts of this nature arise from errors in arithmetic in adding the sum of the saw kerfs of the several saw lines, plus the sum of the several thicknesses of the items to be cut, to determine the setout for the first parallel saw line after the slabbed face has been turned to the knees. When different thicknesses are to be cut from the same cant, miscalculation is more probable than when uniform thicknesses are to be cut.

Evidence of mathematical miscalculation most frequently appears in the dog board unless the sawyer detects the error in time to distribute it over the remaining items. Such practice is of questionable merit.

The sawyer sometimes concentrates on sawing for grade by setting out for taper and slabbing lightly on the first side to obtain the minimum width of face for a merchantable grade. He may similarly concentrate for grade in sawing the opposite face, if it is also of high quality, also setting out for taper. When he gets into lower grade materials and sets to take the taper cut, however, the sawyer must take into consideration the number of cuts left

in the cant. The scale board or dial, referred to in Part II, if correctly calibrated proves a helpful tool in setting the position of this first parallel cut on the opposite face.

If only one thickness is to be cut when sawing a log through and through, the problem is a simple one. The scale board, if it is correctly calibrated, indicates the minimum acceptable size of cant for multiples of the established thickness and includes the sum thickness of the saw kerfs to be taken out. The sawyer can read directly from the scale board the number of cuts present in the cant and place his first parallel cut at the correct position to produce them. As pointed out in Part II, however, the minimum acceptable size at most mills and the exact width of saw kerf will often vary from the averages used in constructing the scale board. The cumulative nature of these errors results in a dog board of considerably different thickness than intended.

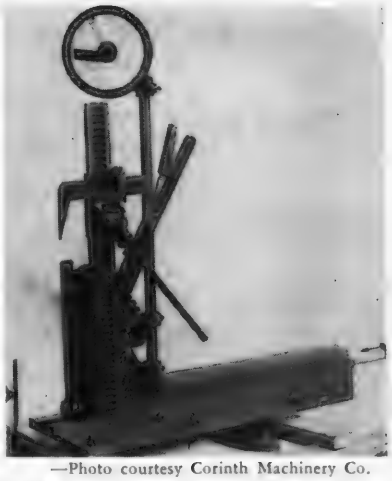
For example, a mill cutting nominal 1-inch pine lumber ascertains that each board must be cut green to 34/32 inches in order to surface to the standard dry thickness of 24/32 of an inch—the standard in some areas for nominal 1-inch softwood material. The 34/32 inches was determined as follows:

Standard thickness, dry, surfaced—24/32"
Allowance for shrinkage in drying—2/32"
Allowance for dressing—4/32"
Allowance for variation in sawing—4/32"
Total—34/32"

If the kerf cut at the mill in this example is 9/32 of an inch, each 1-inch board will require 43/32 inches of the cant. A scale board calibrated for 40/32 inches for each cut would be 3/32 inch in error on the minus side for each cut taken. Conversely a scale board allowing 44/32 inches would be 1/32 inch on the plus side. A 1/32-inch error on ten cuts produces an accumulative error of 10/32 inch. It is, therefore, essential that the scale board be accurately calibrated for the existing conditions. The actual allowance for other thicknesses would have to be calculated for the mill's own standards and the scale, or dial, calibrated to allow for the applicable standards of surfacing, shrinkage, and variation in sawing.

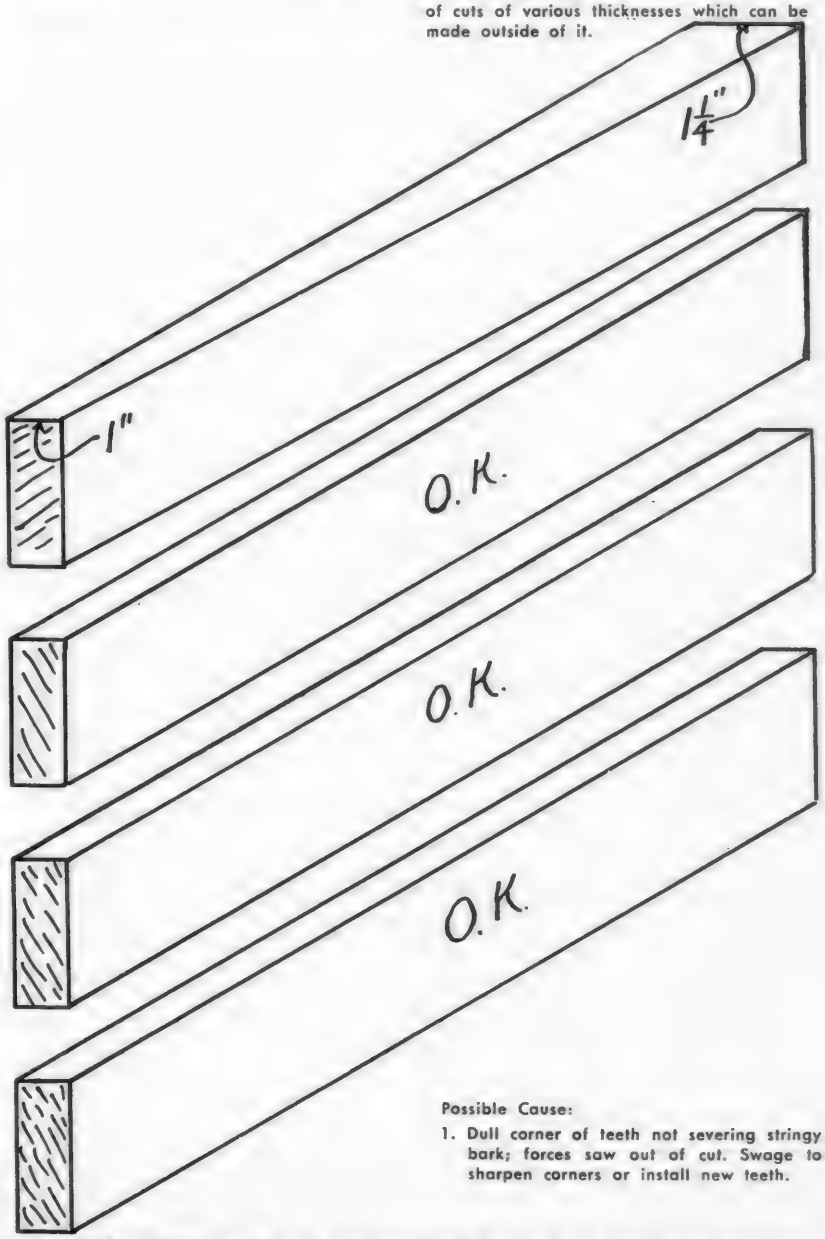
If a variety of thicknesses are being cut, or if the log is to be turned for producing a flitch at the center which will be of a given width, the problem becomes even more complicated. A good sawyer or setterman with a mathematical mind can work out the various combinations involved and produce an accurately cut dog board. Many sawyers lack this ability and scant thicknesses or excessively thick pieces are frequently produced because of the sawyer's inability to figure where the first parallel cut on the opposite face should be placed.

An automatic scale board or dial would be a great aid to the sawyer in placing the first cut. One company now markets a patented dial (Fig. 39) on which the thickness of the flitch desired in the center of the log can be set. The dial then reads in terms of the number of boards and pieces of dimension of the various standard thicknesses that can be obtained outside of the center flitch. Another company has recently put out a plastic horizontal scale board (Fig. 40) on which the index marker can also be set at zero over the thickness of the central flitch desired and the numbers of boards of standard thicknesses ob-



—Photo courtesy Corinth Machinery Co.

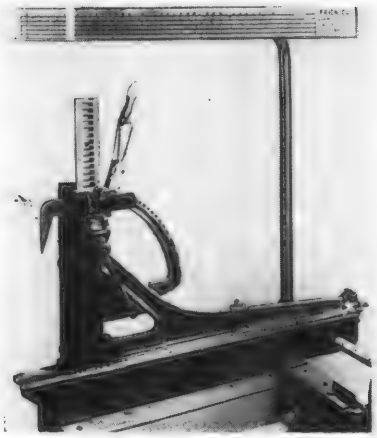
Fig. 39.—Patented scale dial which can be set for width of flitch desired at center of cut and which will then indicate number of cuts of various thicknesses which can be made outside of it.



Possible Cause:

1. Dull corner of teeth not severing stringy bark; forces saw out of cut. Swage to sharpen corners or install new teeth.

Fig. 37.—Board following slab 1" front end, 1 ¼" back end; all other boards satisfactory.



—Photo courtesy Frick Company

Fig. 40.—Horizontal scale board on which indicator can be set to zero for width of flitch desired and which will then give number of cuts of various nominal thicknesses outside of it.

tainable outside of it can then be read directly. Neither of these, however, can be read to give the thickness needed for various combinations of lumber thicknesses.

The problem of mathematical calculation is best solved under present conditions by constructing charts based on the mill's own standards which show the total cant thickness necessary for the most common combinations of lumber thickness. A sample chart has been constructed on the basis of an average shrinkage in drying of 1/16 inch per inch of thickness plus allowances for dressing of 1/8 of an inch, for variations in sawing of 1/8 of an inch, and for saw kerf of 9/32 of an inch.

Every mill should determine its own variables and incorporate them into a series of charts as illustrated in Table 1. Since kerf allowance varies with the width of the saw teeth, some mills will need more than one set of charts to compensate for different tooth widths used for summer and winter sawing. Many mills find it necessary to alter the shrinkage allowance for different species. In cutting dense hardwoods a shrinkage allowance of 1/16 inch per inch of thickness is often inadequate. Mills sawing softwoods and selling their product on a "shipping dry" basis frequently find 1/16 inch to be a wasteful shrinkage allowance. The variation in sawing factor of 1/8 inch, as cited in the example, may be entirely too generous a standard for many mills in constructing a chart for total cant thickness.

Once standard values are determined satisfactorily for the individual mill, they should be incorporated in a series of charts like those which appear in Table 1 for the guidance of the sawyer or block setter. A still more useful method is to put the most commonly used charts on a paper overlay and cement them to the scale board in order to give the sawyer a more accurate indication of where to place the first cut on a cant so as to come out with a dog board cut to standard size. The construction of a home-made scale board for small mills is described in mimeograph R899–18, available free from the U. S. Forest Products Laboratory, Madison, Wisconsin.

If the mill is cutting boxed-heart timbers from the center of some of the logs, in addition to flitches for resawing, additional charts would be necessary. The extra charts would show the minimum timber dimensions decided upon, plus the multiple dimensions of the side cuts from outside of the timber.

In case the log does not prove to be of structural quality when the side cuts have been taken off, many operators, to be on the safe side, use an allowance for the timber which is equivalent to multiples of standard lumber cuts or flitch widths rather than the minimum dimensions of the timber that might be produced. Such practice results in a higher lumber recovery than the hit-or-miss method of placing the outside cut so as to produce only standard-sized timbers. Use of the hit-or-miss method often results in the production of timbers averaging 3/4 inch oversize due to miscalculation.

The Problem of Low Production

Almost any mill can produce accurate lumber if it is "babied" along and run slowly and meticulously. Accuracy at the expense of production is not the objective of this Handbook. It is

CALCULATION OF STANDARD THICKNESSES

Nominal Thickness	Standard S4S, Dry	Dressing and Variation Allowance	Shrinkage Allowance	Minimum Size Rough Green	Saw Kerf Allowance	Total Cant Width
1"	3/4"	1/4"	1/16"	1-1/16"	9/32"	1-11/32"
1-1/2"	1-5/16"	1/4"	3/32"	1-21/32"	9/32"	1-15/16"
1-3/4"	1-7/16"	1/4"	1/8"	1-13/16"	9/32"	2-3/32"
2"	1-3/4"	1/4"	1/8"	2-1/8"	9/32"	2-13/32"

CALCULATION OF STANDARD FLITCH WIDTHS

Nominal Width	Standard S4S, Dry	Dressing and Variation Allowance	Shrinkage Allowance	Minimum Size Rough Green
4"	3-5/8"	1/4"	1/4"	4-1/8"
6"	5-5/8"	1/4"	3/8"	6-1/4"
8"	7-1/2"	1/4"	1/2"	8-1/4"
10"	9-1/2"	1/4"	5/8"	10-3/8"
12"	11-1/2"	1/4"	3/4"	12-1/2"

Table 1.—CHARTS OF TOTAL SIZES OF CANT NEEDED

Chart I.—SIZE OF CANT FOR MULTIPLES OF DIFFERENT SIZE CUTS

Nominal Thickness	Number of cuts							
	1	2	3	4	5	6	7	8
	Total thickness in inches							
4/4	1-1/16	2-13/32	3-3/4	5-3/32	6-7/16	7-25/32	9-1/8	10-15/32
6/4	1-21/32	3-19/32	5-17/32	7-15/32	9-13/32	11-11/32	13-9/32	15-7/32
7/4	1-13/16	3-29/32	6	8-3/32	10-3/16	12-9/32	14-3/8	16-15/32
8/4	2-1/8	4-17/32	6-15/16	9-11/32	11-3/4	14-5/32	16-9/16	18-31/32

Chart II.—SIZE OF CANT FOR DIFFERENT NUMBERS OF 8/4 INCH CUTS WITH REMAINDER CUT INTO 4/4 INCH

8/4 inch cuts		Total width needed for added no. 4/4 inch cuts						
No.	Total Width (Inches)	1	2	3	4	5	6	7
		(Thickness in Inches)						
1	2-1/8	3-15/32	4-13/16	6-5/32	7-1/2	8-27/32	10-3/16	11-17/32
2	4-17/32	5-7/8	7-7/32	8-9/16	9-29/32	11-1/4	12-19/32	13-15/32
3	6-15/16	8-9/32	9-15/16	10-31/32	12-5/16	13-21/32	15	16-11/32
4	9-11/32	10-11/16	11-1/32	12-3/8	13-23/32	15-1/6	16-13/32	17-3/4
5	11-3/4	13-7/32	14-1/4	15-29/32	17-1/4	18-19/32	19-15/16	21-9/32
6	14-5/32	15-1/2	16-27/32	etc.				
7	16-9/16							
8	18-31/32							

Chart III.—DIFFERENT SIZE FLITCHES AND 4/4 INCH LUMBER

Flitch Nominal	Actual (Inches)	+1 cut	+2 cuts	+3 cuts	+4 cuts	+5 cuts
			(Thickness in Inches)			
4	4-1/8	5-15/32	6-13/16	8-5/32	9-1/2	10-27/32
6	6-1/4	7-19/32	8-15/16	10-9/32	11-5/8	12-31/32
8	8-1/4	9-19/32	10-15/16	12-9/32	13-5/8	14-31/32
10	10-3/8	11-23/32	13-1/16	14-13/32	15-3/8	17-3/32
12	12-1/2	13-27/32	15-3/16	16-17/32	17-7/8	19-7/32

(For each cut of 8/4 inches substituted for 2 4/4 inch cuts, subtract 9/32 inch.)

Chart IV.—DIFFERENT SIZE FLITCHES AND 8/4 INCH LUMBER

Flitch Nominal	Actual (Inches)	+1 cut	+2 cuts	+3 cuts	+4 cuts
			(Thickness in Inches)		
4	4-1/8	6-17/32	8-15/16	11-11/32	13-3/8
6	6-1/4	8-21/32	(etc.)		
8	8-1/4				
10	10-3/8				
12	12-1/2				

recognized that the productivity of the small mill is seemingly often of greater necessity, in order to have a profitable operation, than the size accuracy of the product. In reality the two opposing practices can be compromised to return even greater profit by intelligently aiming for the maximum degree of accuracy possible without unwarranted sacrifice in productivity. A mill operator definitely should not aim for productivity without regard for accuracy, or for accuracy without regard to its effect on productivity.

Edging and Trimming Accuracy

In the small mill, the headrig is the most prominent source of sawing errors and for that reason this Handbook has been dedicated largely to the matter of improving sawing accuracy at that point. However, both the edging and trimming operations are points in the mill at which inaccuracies develop in the size of the final product.

Edgers should be sturdily constructed, well maintained, and accurately operated in order to minimize waste in edging. On edgers with movable saws, the saw guides should be tight to prevent excessive play in the saw as it turns on the mandrel. It is not uncommon to find loose guides on edger saws that permit from 1/4 to 3/8 inch variation from the interval set, depending on whether the guides moved the saw in or out to make the cut. Failure to file edger saw teeth straight across or continuing to use them when the corners have been knocked off on one side are other common sources of edging inaccuracy.

Edger feed rolls should be straight and not tilted or bowed, or feed will not be straight and "rainbow-shaped" lumber will be the result.

A shadow-line, electric light guide mounted above an edger, which is in good condition and geared to it, is a tremendous help in minimizing waste and producing accurately edged lumber. A shadow-line is projected on the board where the fixed-saw cut will be made and also along the line of each movable saw. The edgerman can consequently see exactly where each cut is to be made, and align the board to produce maximum scale and grade.

Trim saws should be accurately positioned and carefully operated to minimize waste. Some mills delay final trimming until after drying has been completed so that drying checks can be cut off in the trimming operation. Other mills trim the green material to final length and depend on end coatings or the characteristics of the species to minimize drying defects. An automatic end coating device has been developed for Canadian-type trim saws.

In both edging and trimming, the machine operators should be thoroughly familiar with the applicable lumber grading rules for the species so that the lumber is not edged or trimmed unnecessarily close. This is particularly important in hardwoods where some wane is allowed even in the highest grade.

Summary

Trouble shooting can be minimized in any sawmill by practicing "preventive maintenance." Routine checking of the entire mill setup, including alignment and level of the ways and tracks; the carriage and its accessories; and the mill itself, including husk, mandrel, bearings, saws, and lead, will do much to improve the quality of lumber sawn in the small mill. Accuracy of calculation of the thickness to be obtained from a cant or flitch is almost equally important. The aim should be to minimize both mechanical and human errors in the operation of the mill.

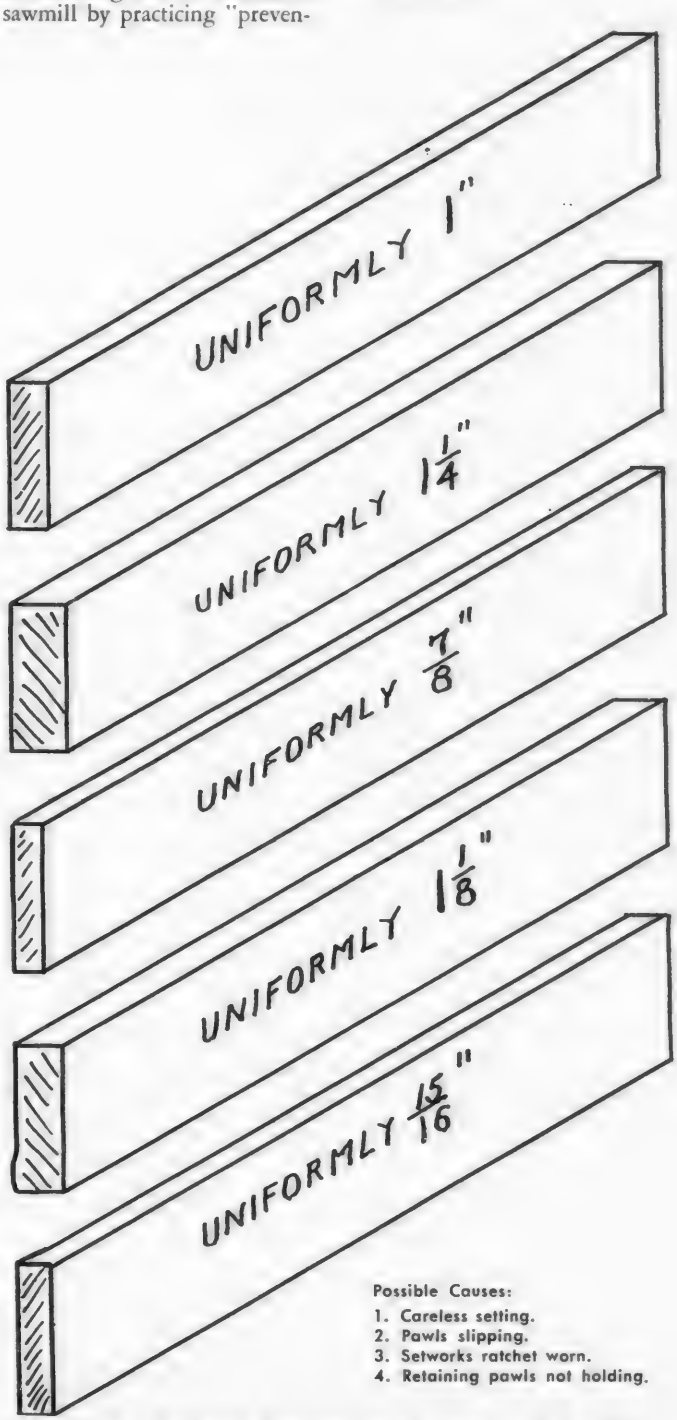


Fig. 38.—Five boards from same log or squared cant; set for 1".

Effect of Incising Beech Cross Ties

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Incised and unincised beech ties were air seasoned and then treated with coal-tar creosote by the double Rueping process to determine possible advantages of incising. The difference in quantity of water lost from each group of ties was insignificant. Sampling for penetration results indicated that benefits of incising could be inferred from sections made immediately after treatment. Improved penetration and uniformity of diffusion of the creosote was noted in samples sectioned three months after impregnation.

THE INCISING OF CROSS TIES is often mentioned even by the earliest literature and handbooks on wood preservation as an effective means of improving penetration in the more resistant species. However, it has never been used extensively by European railroads, owing to the availability of easily penetrated species. In the United States, where for a considerable length of time incising has been standard practice for Douglas-fir, it is believed that its application to other species or for uses other than improving penetration has not been on a full scale until more recent years.

In a relatively short time, incising has gained popularity and large scale application in the Middle West, East Coast, and South of the U. S., not only with the aim of a more efficient treating operation, but also a means of obtaining better and more uniform air seasoning with a minimization of the accompanying hazards of splits, checks, and the like.[1]

The results claimed in favor of this practice have attracted the attention of several European countries where, however, problems relating to the species of wood are quite different from those prevailing in the U. S. Since the benefits of incising seem to be more or less general or at least related to a number of species and not limited to one species only, the desire to investigate the practice with regard to European species (mainly hardwoods) has rapidly gained strength.

Available Data

Certain information reported in the American technical press was taken as a basis of this work.

The report "The Value of Incising Hardwood Cross Ties" by R. Rand (1)[2] gave some interesting aspects of the danger resulting from checks and splits in hardwood cross ties. The Rand report contains a table, extracted from the 1952 AREA Proceedings, which has been taken as a model for Tables 2 and 3 in the present work.

A great deal of subsequent information, expressed in the percentage of ties removed from tracks for mechanical defects due to splitting and checking, is contained in American and European technical literature. European wood preservers, as are those in the U. S., are keenly aware of the importance of this problem; significant statistics have been compiled on this question, for instance, by Germany.

Recently in the U. S., Clarence S. Burt (2) mentioned that of approximately 30,000 oak ties removed from test sections, 48.8 per cent had failed because of excessive checking and splitting. He further pointed out that after oak cross ties are placed in track, checking and splitting develop to the extent necessary to cause replacement as follows:

1 to 5 years	0
6 to 10 years	1.1%
11 to 15 years	13.5%
16 to 20 years	23.1%
after 20 years	11.1%

It seems, therefore, that the removal of ties because of splitting does not follow a constant trend during the years. While no failures are attributed to this cause during the first five years of life, removals increase from then on, until they reach a maximum between 16 and 20 years of life. After 20 years, the rate of development of new substantial checks tends to diminish.

While incising seems to give overall beneficial results, no information to our knowledge shows the behavior of incised ties in the various stages of their entire life cycle, which begins, not when they are installed on tracks, but when they are actually manufactured. It would be interesting to get a complete picture of this behavior from the birth of the tie to its death, taking into account all the effects of incising both from the viewpoint of the prevention of checks and the prevention of decay through a better treatmen

Different species of wood react differently to incising. Insofar as incising tends to prevent checking, it would particularly benefit more those species that develop larger checks affecting mechanical resistance and/or those species that develop checks earlier in their lives. On the other hand, since incising is claimed to bring about better and more uniform penetration and diffusion, it would benefit to a higher degree those woods that are more difficult to penetrate by ordinary treatment.

The overall picture is a combination of those factors and it is to be hoped that some important and comprehensive work will be done so that a complete picture of this problem can be drawn.

This paper will illustrate an experiment that, on a limited scale, has been made along the previous lines.

Purpose of Test

The Societa Italiana Rueping (Italian Rueping Company) has been working nearly 50 years on an exceedingly high percentage of hardwoods in proportion to pine (*Pinus laricia*, var. *calabrica*), which is the only softwood used and on a very limited scale. The main species of hardwoods used are beech (*Fagus silvatica*), oak (*Quercus cerris* and *Quercus sexiliflora*) and, to a minor extent, eucalyptus and secondary species of oak (*Quercus ilex, Quercus pedundulata*, etc.).

This is consistent, of course, with the predominant species to be found in the country and with the utilization of them by the Italian railroads.

The ratio of utilization of the three main hardwoods (beech and the two above-mentioned oaks) depends on various factors such as availability and level of price (particularly for beech). Technically speaking, however, beech is considered the best cross tie if properly treated, notwithstanding its liabilities in the green state and during the seasoning stage.

In fact, as is well known, the beech cross tie is used very extensively in

[1] Credit is given to the work of many American railroads and to such reports as appeared on this subject in the American Railway Engineering Assoc. Proceedings, American Wood Preservers Assoc. Proceeding and FPRS literature during the past five years

[2] Numbers in parentheses refer to literature cited.

The Author: G. F. Franciosi received engineering degree from University of Rome in 1936, worked as assistant architect on Italian Pavilion at New York World's Fair in 1938–39. He joined Societa Italiana Rueping in 1940, was appointed General Manager in 1945, became President in 1953. The firm introduced pressure systems in Italy and built first plant in 1910.

Europe and, on the whole, more than any other species. It has already demonstrated the longest useful life and its treatment is still subject to refinements.

Beech requires more absorption than oaks. While oaks are treated with a standard Rueping process, beech is submitted to a "double Rueping" process, which has been used for many decades. This consists of two consecutive standard Rueping processes; the second treatment being more severe than the first with regard to air and oil pressure. Beech is a non-refractory wood and absorbs creosote with relative ease. The double process does not aim at increasing the absorption, but at obtaining a more uniform penetration and diffusion with a minimum of oil.

In 1954, the Rueping Company began some tests to ascertain the effect of incising on beech cross ties. The experiment was aimed primarily at studying the effects of incising during the seasoning period, which is a very delicate period for the species, and secondarily at determining how incising affected treatment. A heavier retention was not considered desirable since it is unnecessary and even objectionable from an economic point of view.

The possible benefits of incision are claimed in technical literature to be the following:

1. Less splits and checks
2. Shorter seasoning time in the yard
3. Reduced pressure period during treatment
4. Lighter or equal preservative consumption (net retention)
5. More uniform penetration of preservative
6. Deeper penetration of preservative
7. Drier ties after treatment

Seasoning

Method of Selection of Ties: In the beginning of July, 1954, a total of 510 beech ties of second class special, 260 x 23 x 14 centimeters (approximately 102 x 9 x 5½ inches), used on main traffic routes, were selected from incoming railway cars. Although it was not possible for practical reasons to secure completely green and freshly cut material, ties were selected at random from a load that appeared to be comparatively green and which came from one single area of production. As soon as selected, the ties were placed in the shade and half of them, still chosen at random, were incised.

Table 1.—EFFECT OF SEASONING

	Weight Before Seasoning (kg)	Weight After Seasoning (kg)	Difference	Loss of Moisture in Percentage of Original Weight
Stack 1 (255 Incised Ties)	19,307	16,382	2,925	15.15%
Stack 2 (255 Unincised Ties)	19,588	16,456	3,132	15.99%

Method of Incising: The ties were incised with a homemade motorized machine built for this purpose which contained a drum carrying standard incising teeth 7/64 inch thick, Greenlee pattern (3). The incising roll, loaded with strong springs against a free roll, was motorized through a reducer and rotated at slow speed. With this arrangement, ties fed manually to the rolls came out incised on one face only. The wide variation between the two cross dimensions of this class of ties necessitated the different setting of the incising roll springs. Therefore, all of the 255 ties were passed twice through the incising machine along the two wider faces. Adjustment of the springs was then made and the ties were again passed twice through the machine to incise the two narrow sides.

It is to be noted that although second class special ties are comparatively regular, they are still at least partly hewn and often have rounded corners and slight depressions. Therefore, the incisions were not as regular as desired in regard to depth and the procedure is to be considered only mildly satisfactory.

Seasoning Method: After incising was completed, the ties were stacked, the stacks weighed and then brought into the open seasoning yard. Two single stacks were made in the yard; one containing the 255 incised ties and the other the 255 unincised ones. The ties were stacked with the customary method prevailing in the Rueping plant; that is, superimposing by lift truck five unit loads of 51 ties each. The unit loads were built up in a "Z" type of stacking with layers of nine ties alternately supported on one side or the other by a stringer tie.

The orientation of the ties was such that the parallel ties of each layer ran in a North–South direction while the stringer ties ran in an East–West direction. The two stacks were placed in an isolated spot in the seasoning yard so that they were not protected from the wind, sun, and rain by other stacks and sufficiently apart from one another so as not to screen each other. During the course of the day, the sun shone on the East and then on the South and West faces of the stacks; the North sides, although affected by all other atmospheric conditions, were not reached by direct sunlight.

The ties remained in the yard for six months—from July 1954 to January 1955. This is substantially above the normal seasoning cycle for beech during that period of the year. In January, because the weather had been rainy, the stacks were transferred to a covered, ventilated shed in order to dry their surfaces. This precaution was taken so that the utmost accuracy could be obtained in measuring the real checks that had developed, since in rainy weather checks tend to close temporarily and be less apparent.

In general, an effort was made to subject these ties to severe drying conditions in order to put into best possible evidence the different behavior of the two types. For the same purpose, no check irons were set on the ends of the ties and those few existing upon arrival were extracted.

Results of Seasoning Cycle

At the end of February 1955, the surface of the ties was dry enough to put in sufficient evidence all existing checks. The two stacks were then weighed and the results were recorded as shown in Table 1.

Two gauges, consisting of strips of steel ½ inch wide and thickness of ⅛ inch and ⅜ inch respectively, were used to classify checks. Those checks into which the ⅛-inch gauge could not be inserted were classed as Group 1. Checks that permitted the insertion of the ⅛-inch but not of the ⅜-inch gauge composed Group 2, while Group 3 comprised all checks that freely permitted the insertion of the ⅜-inch gauge.

The ties were then classified according to the width of their checks. The widest check present on the tie classified it as belonging to Group 1, 2 or 3. For example, if a tie showed one or more checks belonging to Group 2 but no checks belonging to Group 3, the tie was classified as Group 2, regardless of the number of checks of Group 1. This procedure was adopted for the sake of simplicity and was justified by the belief that the size of the checks is more important, within limits, than the number. The incisions themselves, which could rightly be considered as artificial checks, did not alter this classification, since their width was less than ⅛ inch.

Table 2.—END CHECKS

No. of Ends Examined	Exposure	Group 1 Ends with no checks or checks less than 1/8"		Group 2 Ends with checks between 1/8" and 3/8"		Group 3 Ends with checks wider than 3/8"	
		255 Unincised Ties (510 Ends)					
		No.	%	No.	%	No.	%
224	North	166	74.1	54	24.1	4	1.8
224	South	159	70.9	55	24.5	10	4.6
31	East	23	74.2	7	22.6	1	3.2
31	West	17	54.9	11	35.5	3	9.6
510		365	71.6	127	25.0	18	3.4
		255 Incised Ties (510 Ends)					
		No.	%	No.	%	No.	%
224	North	193	85.8	28	12.9	3	1.3
224	South	175	77.8	43	19.6	6	2.6
31	East	24	77.4	5	16.1	2	6.5
31	West	25	80.6	6	19.4		
510		417	81.4	82	16.4	11	2.2

The checks present on the ends of the ties were the first to be measured and recorded. According to the size of the widest end check, cross ties were divided into classes as shown in Table 2.

Immediately after completing this operation, each cross tie was examined on the four faces and the widest check measured. The ties were grouped accordingly and a further subdivision was made separating ties which were on the outside of the stack (stringer ties and the two external ties of each layer) from ties that were on the inside and therefore more protected from atmospheric effects. It was neglected to count as external ties the seven internal ties of the uppermost layer which really should be considered as external, since they were constantly exposed to the sun.

Discussion of Results of Seasoning Cycle

Loss of Moisture During Seasoning Cycle: Table 1 does not show a more pronounced drying of incised ties than of unincised ones. On the contrary, it shows a slightly higher loss of moisture for unincised ties.

The obvious conclusion to be drawn is clearly not valid since, even though it still remains to be proved that incising actually helps in evaporating moisture, it certainly cannot prevent it. Therefore, it is to be assumed that the results of Table 1 do not give any data as to the effect of incising on the drying time and that the results noted are only accidental.

Admitting that the incised and unincised ties had the same average moisture content on arrival at the plant, proper consideration should be given, for example, to the possibility that the moisture content of the incised ties had been lowered prior to weighing by their individual handling and exposure to air during the several days required for the incising operation. On the other hand, the unincised ties, which had been stacked in unit loads immediately upon their arrival, were not moved or disturbed in any way until the weighing took place.

Moreover, the two stacks were subjected to a total of more than seven months' drying (the last month and a half under cover) and this is an unusually long period for the climate of Southern Italy. It may be that incising accelerates drying during the first few months of seasoning and that the curve then levels off towards equilibrium, so that after a longer period it does not make much difference in this regard whether timbers are incised or not.

Width of Checks on the Ends of Ties: Although incising is primarily intended to decrease checks on the surface where it is actually applied, that is, on the sides or faces of the cross tie, the investigation was extended to the checks on the ends of the ties to ascertain this possible secondary effect.

Table 3.—FACE CHECKS

No. of Faces Examined	Position in Stack	Group 1 Faces with no checks or checks less than 1/8"		Group 2 Faces with checks between 1/8" and 3/8"		Group 3 Faces with checks wider than 3/8"	
		255 Unincised Ties					
		No.	%	No.	%	No.	%
81	External	23	28.4	48	59.2	10	12.4
174	Internal	82	47.1	81	46.5	11	6.4
255							
		255 Incised Ties					
		No.	%	No.	%	No.	%
81	External	45	55.5	31	38.2	5	6.3
174	Internal	123	70.7	50	28.7	1	0.6
255							

Table 2 offers some degree of confirmation of that which was expected; namely, that incisions do help in a more uniform seasoning with smaller checks also at the ends of the cross ties. Although the difference in behavior between incised and unincised ties is not very pronounced, all listed figures (with one single statistically insignificant exception) indicate this trend.

Against too broad an interpretation of this result, it must be noted that, as previously mentioned, antichecks irons were not applied, so as to bring out more into evidence any difference in behavior. Furthermore, the two stacks were completely isolated in the yard and exposed to the sun on three sides during the course of the day. In normal conditions, the application of check irons and the customary seasoning in the yard with stacks set at short distances from one another so as to minimize the direct effects of the sun would tend to decrease end checks. Therefore, it can be concluded only that a difference in behavior does seem to exist, but is not so well defined as to definitely recommend incising for this particular purpose.

Width of Checks on Faces of Cross Ties: Here is a clear-cut difference between incised and unincised ties. Table 3, which groups ties according to whether they were external or internal to the stack, illustrates this difference.

As is well known, the position of the tie, whether external or internal, has a great deal to do with the presence of checks and with their extent and magnitude. It is interesting to note the relative importance of position and incising. Table 3 indicates that, if an internal unincised tie shows smaller checks than an external unincised tie, an external incised tie behaves better than an internal unincised one. The best behavior is to be attributed to internal incised ties.

The division of the size of the checks in three columns, whether they are smaller than 1/8 inch, between 1/8 and 3/8 inch, or larger than 3/8 inch, is clearly an arbitrary one insofar as it can not be generically stated at what point the width of a check begins to become harmful. It can probably be assumed that checks under 1/8 inch are admissible and do not mechanically weaken the tie. If, for clarity's sake and without attaching any absolute value to this terminology, we call "objectionable" all checks wider than 1/8 inch, and further classify as "dangerous" those objectionable checks which are above 3/8 inch in width, the results of Table 3 could be expressed as follows:

a) Of 100 unincised external ties, nearly 71.6 per cent show objec-

tionable checks after seasoning and 12.4 per cent show dangerous checks.

) Of 100 unincised internal ties, nearly 52.9 per cent show objectionable checks and 6.4 per cent show dangerous checks.

) Of 100 incised external ties, 44.5 per cent show objectionable checks and 6.3 per cent show dangerous checks.

) Of 100 incised internal ties, approximately 29.3 per cent show objectionable checks and 0.6 per cent show dangerous checks.

It can be seen that the benefits of incising are unquestionably clear and statistically acceptable. When comparing external unincised and incised ties, the effect is quite conspicuous. The difference in behavior due to incising between internal incised and unincised ties is equally apparent, since incised ties show only slightly more than half the objectionable checks of unincised ties and dangerous checks practically disappear.

Needless to say, the full effect of incising on checks can be evaluated only after the ties have completed their life-cycle in track. For this purpose, this particular lot of cross ties will be installed, alternating incised and unincised ties, on a tract of the Italian State Railways line from Tortona to Arquata.

Treatment

Upon completion of seasoning, the complete lot of 510 ties, consisting of 255 incised and 255 unincised ties, was treated by the double Rueping process employing pure creosote. Two cylinder charges were made up, one containing incised and the other unincised ties and the charges were introduced into separate pressure cylinders of a somewhat ample capacity. The charges were not completed with other materials.

Previously, 16 cross ties of an average size and appearance had been selected—eight for each charge. These ties were loaded and distributed symmetrically in the center truck of each charge, so as to obtain an average behavior. These same ties, eight incised and eight unincised, were to be sectioned to ascertain penetration.

The double Rueping process was run in parallel for the two cylinders. Since behavior of unincised and incised ties in regard to rate of absorption could possibly be widely different in one way or another and since undue high absorption was not desired in either one of the cylinders, it was decided that one of the variables during pressure time would be continually adjusted for the cylinder containing incised ties. Namely, the delivery of the pressure pumps pumping oil was not kept equal in the two cylinders but the pressure pump of the cylinder which contained unincised ties was run at customary regime for similar material, while the pressure pump connected to the cylinder containing incised ties was run at a speed to assure at all times the same gross absorption that was being obtained in the other cylinder. In this manner, the input of oil into the incised ties was at the same rate as for the unincised ties so that at the end of each pressure period, exactly the same gross absorption was obtained in both cylinders.

The double Rueping process consists of two consecutive Rueping treatments. It was observed, although no reason for it is clear, that during the first Rueping treatment at the end of the oil pressure period, when the same gross absorption of 8 liters (approximately 8½ qts.) per tie had been obtained, a pressure of 7.5 kgs. per square cm. (107 psi) was reached in the cylinder containing the unincised ties and a pressure of 7.0 kgs. per square cm. (99.5 psi) in the cylinder containing the incised ties. During the second treatment, when a gross average absorption of 16 liters (17 qts.) per tie was obtained, unincised ties reached a pressure of 10.75 kgs. per square cm. (153 psi) while incised ties reached a pressure of 11.5 kgs. per square cm. (163.5 psi).

All phases of the process, other than oil delivery during pressure periods, were exactly the same in both cylinders.

The description of the treatment follows:

First Treatment:

Air Pressure: 3.5 kgs. per square cm. (49.8 psi); 40 minutes duration after reaching the required pressure.

Oil Pressure: Temperature of oil: 90° to 92° C.; gradual compression for 40 minutes, at which time a gross absorption of 8 liters (8½ qts.) per tie was obtained.

Vacuum Period: 60 minutes duration at 600 mm. (23.6 inches) of mercury.

Second Treatment:

Air Pressure: 3.5 kgs. per square cm. (49.8 psi); 40 minutes duration after reaching the required pressure.

Oil Pressure: Temperature of oil: 93° to 95° C.; gradual compression for 100 minutes, after which the required gross absorption of 16 liters (17 qts.) per tie was obtained.

Vacuum Period: 90 minutes duration at 600 mm. (23.6 inches) of mercury.

Total duration of process, including introduction and extraction of charges, was approximately eight hours.

Results of Treatment

It was decided to measure the absorption on the entire charges both by gauge and scale readings.

As is well known, neither of the two systems offers a great degree of accuracy (4, 5) although modern authors seem to prefer gauge readings, provided that there is some uniformity within individual charges and from one charge to the other. Gauge reading is standard in American practice while scale reading is still widely used in some European countries.

Since the charges were processed between two industrial runs of the plant, it was unfortunately not possible to use fresh, completely water-free creosote. Furthermore, the design of the plant is such that, while it was possible to dispose of different Rueping cylinders for the two pressure cylinders and to make separate gauge readings for the two charges, the shape of the Rueping cylinders does not guarantee a very high degree of accuracy for the relatively small differences in final retention. This is because the standard method of measuring retention in this plant is by scale and not gauge readings. The latter method is not provided for by the design of the plant and entails, when applied, very accurate and tiresome controls.

Also, in the plant in question, it was not possible to separate the water condensate obtained during the vacuum periods for the two cylinders but only to collect the total condensate for all the ties.

Finally, it must be noted that scale readings are based on the gross weights of each truckload (43 ties plus steel truck) before and after treatment, and therefore cannot be relied upon as accurate when very slight variations in retention must be observed. The absolute reliability of the small difference in average retention between incised and unincised ties observed by scale readings and noted below as 0.2 kgs. (.44 lbs.) per tie, would entail a high degree of accuracy in the scales which is not practically and constantly obtainable in normal operation.

For the reasons described above and for the other inherent inexactitudes of the two methods of readings, the net retentions were calculated by both methods so as to compare the two results that are tabulated as shown in the two tables at the top of page 268.

GAUGE READINGS			
No. of Ties	Class of Ties	Method of Reading	Net Absorption per Tie
255	Incised	Gauge	10.9 kgs. (24 lbs.)
255	Unincised	Gauge	12.2 kgs. (26.9 lbs.)

SCALE READINGS				
No. of Ties	Class of Ties	Method of Reading	Average Condensate per Tie	Net Absorption per Tie
255	Incised	Scale	0.75 kgs.	10.4 kgs. (22.92 lbs.)
255	Unincised	Scale	0.75 kgs.	10.2 kgs. (22.48 lbs.)

Discussion of Results of Treatment

It can readily be seen that gauge readings indicate a noticeably higher retention for unincised ties. Since the gross absorption was exactly the same for the two classes of ties, the higher net absorption for unincised ties would indicate a higher kick-back for incised ties. This hypothesis was visually substantiated by the drier appearance of incised ties at the exit of the cylinder where, although the incisions showed some free creosote in the bottom of the incision, no dripping was noticed. Inspection of the unincised ties revealed normal minimum dripping.

On the contrary, scale readings do not give the same results, but show a slightly higher absorption for incised ties. It is to be remembered, however, that no distinction could be made between the amounts of water condensate extracted from incised and unincised ties. An average condensate is therefore attributed to each tie regardless of its class. It is apparent that if different volumes of condensate were extracted from unincised and incised ties, the difference in absorption between the two classes could well be increased, nullified, or even reversed.

If one chooses to possibly minimize errors in readings by taking the average of the two types of readings, a net absorption of 10.65 kgs. (23.47 lbs.) per tie would be obtained for the incised ties, against a net absorption of 11.2 kgs. (24.68 lbs.) per tie for unincised ties.

This assumption seems to be confirmed by the more exact readings of the sample ties. These results, although statistically less significant, are certainly more valuable from the standpoint of accuracy of reading, since they eliminate a large part of the uncertainties deriving from mass industrial readings. The 16 sample ties individually weighed on an accurate scale gave the following results:

No. of Sample	Class of Tie	Increase in Weight per Tie		Average Condensate per Tie for the Whole Charge		Net Absorption per Tie	
		Kgs.	lbs.	Kgs.	lbs.	Kgs.	lbs.
1	Incised	9.3	20.5	0.75	1.65	10.05	22.15
2	Incised	9.6	21.2	0.75	1.65	10.35	22.81
3	Incised	8.8	19.4	0.75	1.65	9.55	21.05
4	Incised	10.4	22.9	0.75	1.65	11.15	24.57
5	Incised	8.7	19.2	0.75	1.65	9.45	20.83
6	Incised	8.3	18.3	0.75	1.65	9.05	19.95
7	Incised	9.6	21.2	0.75	1.65	10.35	22.81
8	Incised	8.3	18.3	0.75	1.65	9.05	19.95
9	Unincised	10.9	24.0	0.75	1.65	11.65	25.68
10	Unincised	10.3	22.7	0.75	1.65	11.05	24.35
11	Unincised	11.4	25.1	0.75	1.65	12.15	26.78
12	Unincised	6.7	14.8	0.75	1.65	7.45	16.42
13	Unincised	9.3	20.5	0.75	1.65	10.05	22.15
14	Unincised	10.2	22.5	0.75	1.65	10.95	24.13
15	Unincised	9.0	19.8	0.75	1.65	9.75	21.49
16	Unincised	8.6	19.0	0.75	1.65	9.35	20.61

The average increase in weight for these samples is 9.13 kgs. (20.12 lbs.) per incised tie against 9.55 kgs. (21.05 lbs.) per unincised tie. By adding the average condensate for each tie, the average net absorption would be 9.88 kgs. (21.77 lbs.) per incised tie against 10.30 kgs. (22.7 lbs.) per unincised tie.

Another significant observation is the spread between maximum and minimum absorption figures for the two classes of ties. While for incised ties the individual net absorption varies from a minimum of 9.05 kg. (19.95 lbs.) to a maximum of 11.15 kg. (24.57 lbs.), it varies for unincised ties from a minimum of 7.45 kg. (16.42 lbs.) to a maximum of 12.15 kg. (26.78 lbs.) This seems to indicate that incising does help in obtaining a more uniform absorption within the charge, belittling the difference in absorption in different ties due to heartwood formations, moisture content, etc.

Sectioning of Samples

The ties used in this experiment were forwarded for normal employment on the test track previously mentioned, with the exception of the 16 sample ties, which were kept at the plant for the purpose of sectioning them so as to have a visual inspection of the penetration.

Although sectioning of ties for this purpose should always take place long enough after treatment to give the preservative time to diffuse itself and approximately duplicate what happens in practice, a special procedure was followed in this instance.

J. A. Vaughan (6), while lecturing on a different subject, discussed an interesting aspect of incising. Specifically, he made the observation that in some incised woods like gum, sections made after treating did not show more than slight penetration. However, after three months, when the cross ties were sectioned again, they showed good penetration to the depth of the incisions or better.

It was, therefore, planned to duplicate this experiment, to see not only how incised ties compared with unincised ones in regard to immediate penetration, but also how incising affects the natural penetration that takes place in time. For this purpose, the samples were divided into two groups of eight ties, each group containing four incised and four unincised ties

While one of these groups was sectioned the day after treatment, the second, to be sectioned after three months, was transferred to a covered shed. The incisions on the incised ties had closed up during treatment and had become very thin checks in which, as previously mentioned, some free creosote was visible. It was desired to verify whether this free creosote would leak out of the incisions during handling and storing or would remain there and diffuse itself into the wood. To ascertain this, clean light-colored sheets of hardboard were placed on the floor of the shed and wooden stickers laid parallel on them to support the treated cross ties.

It must be noted that, in this method of grouping, ties were selected so that within each group, incised ties which were evenly distributed on the top and bottom of one cylinder were compared to unincised ties occupying the same position in the other cylinder. No significance had been previously found in regard to the position, but it was thought that a better comparison could be made between ties that had been treated under exactly the same conditions. Unfortunately, this method of grouping introduced an element which must be taken into account when comparing visual results. It happened that within the first group four incised ties were compared with four unincised ties which by chance had received a much higher absorption. Similarly, when comparing incised ties Nos. 2, 4, 5 and 7 with unincised ties Nos. 10, 12, 13 and 15, these latter had a total absorption of slightly less than the incised ties. With this in mind, the interpretation of the photogrpahs will be facilitated.

It is regrettable that, in selecting the ties, attention was not given to the more essential comparison of groups homogenous in absorption, thus giv-

ing a clearer visual observation of the comparative penetration.

In order to best examine the degree of penetration, the following method of sectioning was adopted:

Each tie was sectioned by a saw cut running parallel to the ground face of the ties; that is, to the wide face which is generally closer to the center of the tree and is likely to contain the most heartwood, if heartwood is present in that particular tie. The thickness of the plank thus sawn out of the tie was 1.5 cm (6/10-inch). This plank is shown in the photographs with the sawn side facing upwards.

The remainder of the tie was cross cut into two pieces. One piece was kept integral and is shown in the photographs under the numerical tags. It lies rotated 90° counter-clockwise in relation to the first cut which was mentioned above.

The remaining part of the tie was sawn lengthwise into two halves with the cut parallel to the first lengthwise cut. Of these two pieces, the one in the center of each photo lies on the original orientation, while the outer piece, which is made of the outer and upper face of the tie, is rotated 90° counter-clockwise.

Fig. 1.—Sections of incised ties sectioned immediately after treatment.

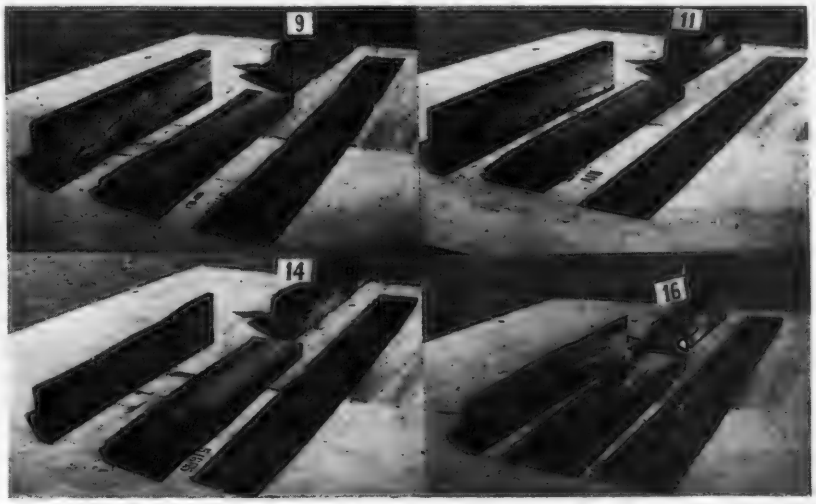

Fig. 2.—Sections of unincised ties sectioned immediately after treatment

Discussion of Results of Sectioning

A visual comparison of the penetration in the first group of ties that was sectioned the day after treatment is difficult because of the difference in absorption. Comparison of photographs is even more difficult since the lightly treated sections of wood cannot be distinguished from the completely untreated parts.

Notwithstanding a satisfactory retention, the penetration in unincised ties, although well marked on the outer layers, was found totally absent in certain areas, even very close to the surface as in ties 11, 14, and 16.

The results of penetration on the four incised ties did not seem to be much more satisfactory, even taking into account the fact that these four ties happened to have had a limited absorption. However, on all four ties and particularly on ties 3 and 8, the full length cut showed clearly the pattern of the incisions, amplified and marked very definitely by creosote, even where the incisions had not reached the desired depth because of imperfect mechanical equipment.

After three months of storage, the second group of ties was examined. The sheets of hardboard which had been placed under the ties were found to be completely spotless, which proves that no free creosote had leaked out of the ties, but had diffused into the wood, completely disappearing from the incisions. It is believed that this is an important point, since leaking creosote could be not only objectionable but also a complete loss from the point of view of treatment.

The sections of these eight ties appear in Figs. 3 and 4. It must be noted for proper evaluation that this time the registered net retention of the four incised ties happens to be slightly higher than that of the unincised ties. Nonetheless, the appearance of the sections is strikingly different.

The pattern of the creosote penetration through the incisions had practically disappeared through diffusion and the overall penetration of ties 2, 4, 5 and 7 is to be considered very satisfactory, since there were no completely untreated parts except perhaps in tie No. 5. Even in this tie, the relatively white center section was streaked by creosote in a way much more visible than shown in the photographs.

In comparison, unincised ties 10, 12, 13, and 15 show completely untreated sections on the full length cut. It is quite apparent that on ties 12 and 15, any small future surface check would open an infection passage to the inner part of the tie.

Conclusions

Italian beech cross ties were incised with standard AREA pattern using a homemade incising machine. The resulting incisions were not as deep as desirable and obtainable with a standard machine. These ties, and an equal number of unincised ties which served as a control, were air seasoned in the Naples area for seven months.

The experiment showed a decrease in the number of incised ties affected by larger end checks but it is not believed that this improvement in itself would justify incising.

Comparison between the two groups in regard to the prevention of large checks on the faces of the ties showed a much more definite improvement for incised ties. Larger checks, which are the most dangerous, were greatly reduced in all incised ties and practically disappeared in those ties that were not exposed to severe seasoning conditions.

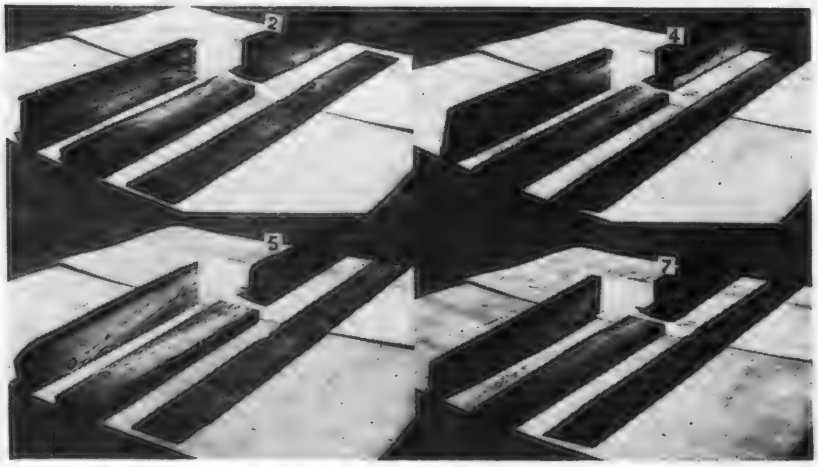

Fig. 3.—Sections of incised ties sectioned three months after treatment.

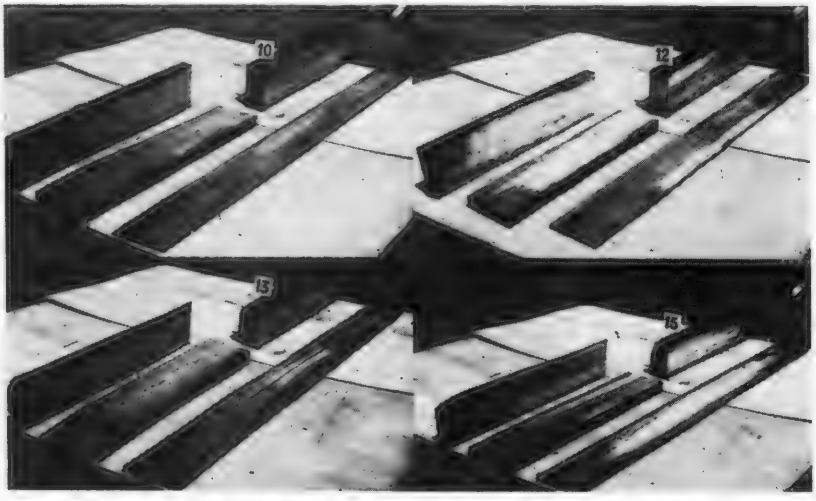

Fig. 4.—Sections of unincised ties sectioned three months after treatment.

No improvement in relation to moisture content at the end of the seasoning cycle could be ascertained and, therefore, no saving in seasoning time could be anticipated for incised ties on the basis of the present experiment.

When incised ties were treated by the double Rueping treatment standard for unincised ties, no significant difference between incised and unincised ties could be found in regard to the oil pressure required for a given gross absorption. It can be safely surmised, however, that incised ties do not retain substantially more—but probably less—creosote than unincised ties when subjected to the same treatment and brought to the same gross absorption.

A smaller spread between minimum and maximum absorption per tie was observed for the incised ties than for the unincised ones.

The lips of the incision closed nearly completely after treatment and some free creosote remained in the crack. It was observed that the relation between the quantities of the free creosote and the width of the cracks is such that the creosote does not leak out in normal handling and storage and is completely absorbed into the tie within a period of three months.

In regard to penetration, the number of samples that were sectioned and individually examined was not sufficient to have high statistical value. While only an indication of the benefits of incising could be inferred from the sections made immediately after treatment, a definite and greatly improved penetration and uniformity of diffusion was noted in the samples that were sectioned three months after impregnation. Although no safe deduction could be made concerning beneficial effects of incising for penetration of the inner part of the tie, all samples showed periferical impregation sufficient for protection for a depth at least equivalent to the depth of the incising teeth.

It is expected that further data on the behavior of the two groups of ties, which have been installed in an experimental tract, will be gathered through periodical inspection.

Acknowledgements

The previous work on this subject by United States scientists and technicians quoted in the preceding pages is gratefully acknowledged. The present study has attempted to duplicate and possibly enlarge it in regard to a European species. The full cooperation of the General Direction of the Italian State Railways, Office of Works, and its permission to use FFSS railway ties are extremely appreciated. Further thanks are expressed to the Italian State Railways for taking upon themselves the task of installing this material in an especially selected tract so as to permit future observation and study.

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Economics of Glued Laminated Structures[1]

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Discusses unique economic factors which affect efficient production and use of glued laminated structural material. Industry terms are defined and brief history of glulam given. Glulam is described as an important factor in helping timber hold its rightful place as a structural material in competition with other materials.

THE STRUCTURAL TIMBER fabricating and laminating industry has made significant steps towards maturity over the last fifteen years. A pattern of economic development has emerged as the result of increasing use and improving technology.

At the outset, it would be well to define some industry terms and present some brief general information so that meanings will be clear. Glued laminated timber structural members are composed of two or more laminations with approximately parallel grain, bonded together by glue and pressure to form a new section. The finished member may be straight or curved and of practically any size. In common use is a rectangular section the net width of the laminations and a multiple of the lamination thickness in depth. The common term used to describe this material is "glulam."

Glued laminated structural members are produced for either exterior or interior use, the criterion being the expected maximum moisture content of the member under service conditions. If waterproof bond is required, a phenolic, resorcinol or melamine glue is ordinarily used. For those uses which do not require waterproof bonds, a casein, room-temperature setting glue is used. Any lumber for which structural grades can be established is potentially usable for glulam. Because of its good supply and well-established stress grades, Douglas-fir is probably the most widely used wood. However, Western hemlock, Southern yellow pine, larch, white and red oak, redwood, Sitka spruce, and others have been or are being successfully used to some degree.

The original glued lamination of structural timber members was started in Germany, from whence it was brought to this country in the early 1930's. With such a new material and with so little background for its production and use, limited quantities of glulam were used, until during World War II critical structural material shortages brought about its use along with great quantities of sawn structural timber. There were those who assumed that, with the end of hostilities, the demand or need for glulam would disappear. On the contrary, the forced development of the technology to meet war needs brought about better and more economical glued lamination as well as a body of basic information to allow the proper specification of this material. The U. S. Forest Products Laboratory at Madison, Wisconsin was responsible during these years for the tests and experiments which are the basis for design stresses and values today. Many individuals and the timber fabricators in the field contributed through their experience, knowledge, and promotion to the acceptance of the material on a wide scale. The tremendous advantages of glulam began to be appreciated by architects, engineers, and others responsible for construction specifications. Regional and national lumber associations and agencies took an active interest through the publication and promotion of data useful in the design and specification of glulam. All such efforts are continuing at an ever increasing rate.

The establishment in 1953 of the American Institute of Timber Construction gives testimony to the growing importance and coming of age of the material and the companies which produce it. A.I.T.C. is composed of 17 active fabricator-laminator members, 29 associate members, who because of their close association with the industry help to support it, and over 100 professional members, all interested individuals in the field of manufacture, design, specification, or construction.

The association issued in 1954 its first edition of Timber Construction Standards. Just recently it has issued an Inspection Manual for Structural Glued Laminated Lumber and an addition to the standards outlining appearance grades. The support of the membership of A.I.T.C. of these standards will do much to promote the unanimity within the industry and the standing of the product with the architectural and engineering professions.

The economics of laminated structural timber can best be broken down to those factors affecting production and those affecting use of the material.

Production Factors

Some of the factors peculiar to the industry which affect production will in all probability lose their significance with further development. An example is the present requirement of specialized custom-built equipment. While a satisfactory laminating job can be accomplished through the careful use of modified standard equipment, production on an efficient quantity basis requires machinery designed and built for the job. This, of course, results in a relatively high equipment cost in relation to production capacity.

The variety of factors which have a profound affect on the reliability of a laminated structural member, such as grade and moisture content of lumber, cleanliness, and smoothness of surface to be glued, proper mixing and handling of glues, machining and positioning of scarfs, speed of lay-up and uniform and adequate pressures, require strict and continuous quality control. This control must be comparable to the most exacting found anywhere in the forest products or furniture industry.

A sincere effort has been made by several members of the timber laminating industry to prevent too much standardization of product. So much of the appeal these products have for the architect and engineer depend upon the flexibility of design which they allow him that to standardize on shapes and sizes would rob the industry of a major sales point. From the standpoint of production, it is therefore obvious that every job is a custom production. On large projects using identical assemblies, this factor loses some of its importance, but since the average job is not large, the lack of

[1] Presented at meeting of FPRS Inland Empire Section, August 4-5, 1955, in Butte, Mont.

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Fig. 1.—Glulam may be easily combined with other materials in a structure. Carpenters handle the erection, eliminating the need for additional trades.

real production runs is a definite economic factor.

The sale of laminated members is usually to a general contractor with the task of incorporating them into a construction project. The speed with which he can complete his project depends upon scheduling various materials and trades efficiently and without loss of time. This requires that the laminator be able to schedule his production several weeks in advance with sufficient accuracy to satisfy his customer's needs. With nearly every project being different from any other, this task assumes sizeable proportions and requires production control systems and personnel of the highest order.

The variables in the production of glulam carry on into the lumber stocks required to offer the full flexibility of design which seems advisable. Grades range in Douglas-fir from No. 2 Structural through B and Better Clears, though most commonly used combinations of grades are composed of one or two of the following: No. 2, No. 1, Dense No. 1, Select Structural, and Dense Select Structural. In addition to this, lamination thickness varies in 1/4" increments from 1/4" through 1 5/8" net to allow bending to desired curvatures. The total number of combinations possible through the application of these variables makes inventory control an important economic aspect of glulam production.

Detailing Important

Sale and production of custom shapes and sizes require accurate and careful detailing to insure dependable results at the job site. Preparation of such details must be by experienced and well-supervised personnel. This necessary function is an economic factor of consequence in any volume commercial production of glulam.

Tied in closely to detailing is the requirement for full scale patterning of all complicated structural shapes. Unless templates have been made, undependable results are evidenced in field assembly and erection difficulties. The requirements for loft space, skilled personnel, specialized equipment, and materials expense are thereby added to the list of special factors affecting production costs.

The problem of predicting costs and arriving at selling prices in the face of all the variables mentioned can pose some knotty problems. It has been quite well established that uniform pricing on a per thousand board foot basis for all shapes, sizes, quantities, and conditions is unrealistic. The problem, then, is one of classifying variables and arriving at methods which will allow rapid and accurate predetermination of costs for any desired combination of requirements. Personnel required for this function is in proportion to total volume of work involved, but in any case must be well trained and under top-flight supervision. Upon the accuracy of the estimating, in a broad sense, depends the financial success of this manufacture.

The traffic and transportation problems attendant upon the shipment of glued laminated structures are, in most cases, quite similar to those faced by the average fir sawmill with some exceptions. Because of the use of curved shapes and the lack of manufacturing premium on long lengths, the problem of shipping such material presents a special aspect. Transportation problems have had the effect of limiting the designs of structures to those sizes than can be shipped by available means. Predetermination of shipability, special loading techniques, and handling problems are considerations which must be faced by the producer of glued laminated structural shapes. In this respect, traffic personnel must be well trained and imaginative. They play an important role in production.

To sum up, the unique economic factors which affect the efficient production of glulam are requirements for specialized plant and equipment, close quality control, nonstandardization of product, production control, inventory control, structural detailing, full scale patterning, custom estimating, and transportation.

Factors Affecting Use

After this brief look at the factors affecting production, let's explore those economic factors which affect the use of glued laminated structural material.

The combination of function, an inherent quality of glulam, is perhaps the most important single factor contributing to the use of this material. It is widely appreciated by architects and others that the expensive decoration or camouflage of structural members for the architectural consideration is a costly practice. Glulam, when used to satisfy a structural function, contributes to the aesthetics as well. The warm natural tones and interesting grain patterns of wood provide a bonus quality not found in other structural materials. When a glulam member is designed to take advantage of the architectural characteristics, some truly striking results are attainable.

Because the material has this quality and because lumber grades do not deal with appearance characteristics, it has been necessary to establish standard appearance specifications. The American Institute of Timber Construction has published the three grades; Premium, Architectural, and Industrial, describing in detail the requirements of each and suggesting

Fig. 2.—Architect's freedom of design with glulam gives each building individuality.

typical uses. The designer is given the opportunity to key the appearance of his structural member to his desired effect. Some fabricators also offer sandblasted, wire brushed, adzed, or factory-stained finishes to further extend the effects available.

A factor of great importance in the use of glulam, sometimes overlooked by architects and engineers, is the ease with which glulam is combined with other materials in a structure. Structural connections are easily made to any secondary framing. Roof decking, interior finish, or wall framing are installed simply and efficiently by regular tradesmen and with common materials. Job site revision is easily accomplished when necessary. Carpenters handle the erection of glulam, eliminating costly layoffs or the need for additional trades. Examples can be cited comparing glulam with other structural systems, having the same costs knocked down at the job site, in which the finished job having glulam framing shows a lower total cost. With the more commonly used construction materials, glulam is incorporated most easily and economically into a structure.

Flexible Design

Rather than being bound by the dictates of a standard structural section, shape, or length in approaching a design problem, the architect or engineer is free to tailor the building's dimensions, clearances, or shape to its function. He knows that a structural system can be developed in glulam without premium cost which will satisfy his requirements. Outstanding examples of this quality are to be found in buildings throughout the land. Structurally framed with glulam, each has an individuality of its own made possible by the architect's freedom of design. The economy due to elimination of unneeded cubage, the reduction of wall heights, reduction of dead loads, and elimination of false effects are some of the results of functional design made possible by glulam's flexibility. Pitched beams, cambered beams, arches of all types, trusses, tapered sections are all available in almost any dimension in glulam.

Glulam is an efficient structural material. Its strength in bending in relation to its weight is the highest of any commonly used structural material. As an example, let us compare glued laminated timber with structural steel, quoting in part from "Fact or Fiction" by Verne Ketchum. Using the accepted average weight per cubic foot of 490 pounds for steel and 32 pounds for Douglas-fir, it is evident that steel is about 15 times heavier than wood. Structural steel has a strength for bending of 20,000 pounds per square inch cross-sectional area. Douglas-fir has an average strength of 2500 pounds per square inch for all combinations of glued timbers. Thus, size for size, glued timbers are one-eighth the strength of steel. By simple proportion, it may be shown that glued laminated timbers are, therefore, 90% stronger by weight than structural steel. This comparison is for normal loading conditions such as would occur under the dead load of the structure and live load of occupancy such as warehouse goods. For short duration and intermittent loads imposed by snow, wind, earthquake, and impact forces, wood has increased strength that permits it to resist even higher stresses with the same degree of safety. Steel does not have this property. So, for snow-combined loads, the percentage value of 90 may be increased 15%; for wind and earthquake, 33%; and for impact 100%.

Shear and bearing-across-grain strength of wood are quite low in comparison with shear and bearing values of steel, but because of their nature cannot be resolved into strength-weight comparisons. Bearing-across-grain strength in wood is applicable primarily to joint design. Vertical shear is of chief concern in steel construction and horizontal shear in timber design. The primary economic importance of this quality is found in the reduction of structural dead load, lower transportation costs, and, in many cases, lower erection costs.

Wherever sizes, lengths, or other characteristics of sawn lumber are adequate to serve a structural requirement, glulam cannot compete on an economic basis from the first-cost standpoint. However, when sizes of sawn lumber become excessive from a drying standpoint and seasoning maintenance or appearance defects become a problem, glulam with its inherent stability in service begins to compete. Prepared as it is from kiln dried boards or dimension stock, glulam is dry throughout. It does not shrink appreciably in service when prepared to proper specifications, thus eliminating bolt tightening maintenance. Checking, if any, is confined to hairline defects of minor consequence. Since camber for expected deflection is easily built into a member during manufacture, members always present a sound and substantial appearance.

Glulam is usually used in a section size of substantial proportions. Since wood is an efficient insulator, members when exposed to fire lose their strength slowly and fail only when a large proportion of their effective section is destroyed. Because of the absence of checking in glulam as found in large sawn timbers, it is considered to be superior in fire resistance to sawn members of equal size. Unfortunately, little consideration is given

to the fire resistivity of heavy timber members by many codes and insurance bodies. Fire loss reports show no differentiation between frame structures and mill or heavy timber structures making true appraisal of loss comparisons most difficult. Because wood is combustible, its use is relegated to minor positions or prohibited completely in certain types of structures. All of the timber fabricators, the American Institute of Timber Construction, and national and regional lumber associations are working on this problem and some results have been obtained; others will follow. At the present time, this circumstance prevents the use of glulam in many structures for which it is ideally suited.

Those economic factors, then, which affect the use of glulam members are its combination of structural function and architectural effect, its ease of integration with other construction materials, its flexibility of design, its inherent efficiency, its stability in service, and the present effects of some codes and regulations. At the present time, the balance of these economic factors is heavily in favor of the use of glued laminated structural members as attested by their growing popularity. Future development within the industry and within other competing industries will bring about revisions in some of these factors. The glued lamination of structural timber is, without question, an important answer coming from within the timber industry to those who ask, "Will timber be able to hold its own as a structural material in competition with the advancing technology in the use of other materials?" Today, the answer is an unqualified yes.

Present and Future Problems of Timber as a Structural Material[1]

PANEL DISCUSSION

Problems faced by structural timber include the need for more scientific knowledge of the material, techniques of structural and architectural design, durability against fire and decay, data on availability of timber and development of a fabricating industry, and knowledge of economic considerations which affect decisions regarding timber's use. Experts in each phase suggest answers to some problems and point to possible solutions of others.

Introduction

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WE IN THE TIMBER business are faced with the problem of retaining and extending our markets. We must compete successfully against substitute materials which have cropped up with specific functional uses. We must fix in our own minds the functional uses of timber forms, such as sawn timber, glued laminated timber, plywood, modified wood such as compreg, hardboard, stressed skin panels, structural combinations of wood and metal, or combinations of wood with other materials.

It has long been a principle in the timber construction industry that a successful timber structure must fulfill three functions: a structural function, that of supporting the externally applied loads; an architectural function, that of enclosing the desired space and serving the needs of use and appearance; and an economic function concerned with fulfilling the other two functions within the bounds of competitive economy.

Now we must consider the specific problems which have arisen as a result of the inroads made upon timber by newly developed synthetic and substitute materials. We must consider also how we can fit timber more efficiently into the functional design picture of today.

To this end we have assembled a panel of experts on the five principal phases into which our problems fall: timber technology, comprising our scientific knowledge of the material itself; technique of structure and architectural design; the durability of timber from the standpoints of its greatest enemies, fire and decay; the availability of timber in future years and the development of an industry concerned with its fabrication; and finally the economical considerations which are of such great importance in reaching most decisions.

Problems of Timber Engineering

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One of the most serious problems facing timber designers today is the natural variability of their construction material. The variability in the strength of the clear, straight-grained wood of any species is considerable and is increased still further by the presence of defects and by the application of fastening devices.

Theoretically, it is impossible to select a fraction of the average bending strength of a species below which no piece could fall. Practically speaking, however, a strength figure can be obtained for a species which will virtually ensure that no weaker piece will be found.

The structural designer in wood is handicapped by the fact that he must design for the assumed minimum strength piece. If he is willing to accept the fact that 1 piece in 40 will probably be weaker than the working stress he adopts, then he is faced with the discomfiting thought that 38 pieces out of 40 will be stronger than is required and will, therefore, be uneconomically utilized. If he is unwilling to take the calcaulated risk of 1 piece in 40 being below strength and bases his working stress on a calculated exclusion of 1 piece in 100, then the degree of uneconomical utilization will jump to 98 per cent of all pieces used.

The need for research into the problems of variability is pressing in view of the competition that structural timber faces from other structural materials. Some way must be found to make safe use of the wasted strength in up to 98 per cent of all timbers now being used. The closest approach to a solution of this problem at the present time is glued laminated construction although glulam construction is not without its own problems in design, lay-up and assembly.

The data so far obtained on thousands of tests on clear, straight-grained specimens of wood provide useful raw material for many statistical studies of the variability problem. The individual test values can be analyzed in many different ways in order to find answers

[1] Presented at annual meeting of FPRS Eastern Canadian Section, March 15-17, 1955, in Montreal, Quebec.

to such questions as the relation of specific gravity to strength, the relation of moisture content to strength, and the variability to be expected when sampling material from a new locality not previously explored.

It has been found that the "spread" of strength values about the averages is greater for the timbers containing defects than it is for the small, clear, straight-grained specimens of the same species. In the derivation of working stresses for structural timbers, an allowance is made for the effect of defects on the strength. The term "strength ratio" is used to denote the ratio of the strength of a timber containing defects to the strength of a clear, straight-grained timber.

It is generally assumed that all species are affected to the same extent by knots of the same size in the same size of timber. This has been studied and found to be generally true of those species that have been tested in structural sizes. For this reason, tables of strength ratios are made applicable to all species and the value for any particular condition is used in conjunction with the strength of the clear wood to obtain working stresses for the structurally-graded timber.

The use of working stresses in the design of structural timber naturally entails the structural grading of timbers to ensure that they fall within the assumed strength ratio limits. Structural grading is by no means an exact science although every practicable precaution has been taken to make it so. The speed of grading and the difficulty of determining at a glance the size of knot and its direction through the timber, the difficulty of ascertaining the density of the wood and the exact nature of all the other defects, all combine to lower the accuracy of strength-ratio determination and, consequently, the reliability of the final grade. It is not surprising, therefore, that the degree of variability is even greater in structural timber than in small clears.

The net result of this compounding of variability is to increase the percentage of structural failures or to decrease the efficiency of utilization depending on the level at which the working stresses are set. At the present time, the efficiency of utilization is low enough to be disturbing to those interested in economical and competitive timber construction while, at the same time, the possibility of failure in low-strength pieces is great enough to be alarming to those perfectionists in the engineering profession who feel that the goal in structural design should be no failures at any time under any circumstances.

Problems of Structural and Architectural Design Techniques

R. A. DOWNING

Manager, Timber Fabricating Division, A. S. Nicholson & Son, Burlington, Ontario

Timber, in comparison with other structural materials, is relatively strong in tension and compression parallel to grain, but weak in shear and tension and compression perpendicular to grain. One unique and important property of timber which should not be overlooked is its ability to withstand, without reduction to the factor of safety, higher stresses induced by loadings which will not be permanently applied to the structure such as live, snow, wind, and impact loadings.

These properties must be kept in mind when determining the structural grid, the form of structural unit to be used, and the design of the unit itself if timber is to be used to its best advantage.

The grid on which the framing will be based is determined largely by the end use of the building. It should be noted that rarely can a grid suitable for steel or concrete framing be economically replaced in timber. The span of the primary members can often be set by striking a mean between what is desired and that which can be economically provided. In choosing the spacing of these primary members, consideration should be given to the availability of commercial sizes of sawn material, and the commercial lengths should be utilized so that wastage is reduced to a minimum.

The form of structural unit employed will be decided by consideration of spans involved, wall construction, whether the building is to be heated or unheated, and interior finish required. For example, a warehouse involving a clear span which on the basis of first cost would economically dictate the use of a truss may, if it is to be heated, justify the use of a compact but more costly beam.

When appearance is a factor, consideration must be given not only to the unit cost of the member but also to finishing costs. Glulam beams are now being widely used in school construction combined with 2 and 3-inch exposed roof decking. Here the economy lies in the elimination of a suspended ceiling and the necessity of furring in the beams. With the use of the modern timber connectors, it is possible in truss work to develop to a fuller degree the strength of material employed.

One of the best comparisons that can be made of taking advantage of timber's strong points is in truss work. With steel, a parallel chord truss may be economical whereas using timber, a bowstring truss is more practical. In a bowstring the top and bottom chord stresses are axial and almost uniform throughout. Further, the shear stresses or web loads are at a minimum. Hence a constant section top and bottom chord can be economically used, and the web connections are simple and more readily made. Even when a flat roof is desired, it is often still more economical to build a bowstring up to a flat roof than to construct a parallel chord truss in timber.

The framing of members to one another often presents a problem, and the connections necessary can become very costly. In steel and concrete, beams and girders can be readily framed together, whereas with timber, since no method has been devised for welding one member to another, excessively large steel assemblies are required. Connections should be kept as simple as possible, both in the form of the steel shapes used and the fabrication of the timber necessary. This can be accomplished if consideration is given to it at the time of laying out the grid.

If the timber fabricating industry is to continue to grow, it will be necessary to constantly promote the advantages of timber as a structural material to the public, the prospective buyers. Further, the curricula at the engineering and architectural schools should include a course in timber design and more detailed information should be available for the practicing consulting firms.

Durability of Timber as a Structural Material

G. E. KERNOHAN

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Timber has more virtues than weaknesses or problems. The difficulty is to get everyone thinking of timber's strong points. We spend too much time bringing out the problems or weaknesses of timber technology, design, production, and durability, and at the same time we continually hear of the strong points of competitive materials. As a structural material, timber has stood the test of time well. Its durability has been proven over and over again.

For more than 100 years, wood preservatives have protected timbers for a long service life against fungi, marine borers, and insects. More re-

cently, timbers have been protected against the hazards of fire by impregnating fire retardent chemicals into the wood. Competitive materials cannot equal records set by timber, yet they are establishing themselves as superior structural materials.

We need make no apologies for timber. We must, however, make known the great developments and strides which have been made through research. Research and time have shown that preservatives, properly impregnated under pressure, prolong the life of timber equal to or beyond the life of other structural material— almost regardless of the conditions to which it may be subjected, including fire.

Durability under fire is one of timber's assets and should be presented as an asset rather than as a problem. Various firms have spent large sums on research in an attempt to develop a surface coating to reduce flame spread and fire. There are on the market recognized chemical mixtures which, when impregnated deep into the timber, become a fire retardent as well as a wood preservative.

An exhaustive list should be made of requirements of structural materials, including cost, maintenance, fabrication, and insurance. It should include such items as: strength in relation to weight, insulation qualities, reaction to various types of fire, ease of workmanship, natural beauty, and the need for facing with other materials in its finished form. There should be a list of all structural materials available, broken down into their many forms and methods of application, including various methods of protective coatings. Then a rating should be established for each material under each application and requirement. This alone would improve the status of timber. Such a compilation would also give direction toward further research.

How do we go about such a program? It is hoped that the Canadian Institute of Timber Construction, through its regional committees made up of lumber producers, timber fabricators, and pressure treating companies, will cooperate, as well as a representation of all interested groups. The approach of each regional group could be organized so that findings can be forwarded to a central body where they can be readily compared and developed.

All of us in the wood industry must stand more closely together, collectively do more industry-wide research and advertising. Competitive industries are spending vast sums in developing new methods, new products, and new fields, and they are making their findings well and broadly known. We must collectively keep timber users and designers fully versed on the results of the many and varied research programs which are being carried out to show the value of timber in all its new developments and uses, and which should keep timber in its proper place as a structural material.

Availability and Fabrication of Structural Timber

T. A. ELDRIDGE

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Canada's forest resources are enormous and, in view of the ever improving tree farming and reforestation practices, they are likely to satisfy demands for domestic use and export for many years to come. Latest available estimates of Canadian timber stocks show reserves of 415,291,000 board feet of timber plus 2,656,025 cords of smaller material which will in due course produce commercial timber. Of this total, 242,072,000 board feet and 1,686,834 cords are readily accessible at present and, as the frontiers of Canada are pushed forward, more of the balance of this natural wealth will become available.

No fewer than 171 different botanical species of softwood and hardwood are grown in Canada and the great majority is utilized as sawn lumber. By far the greatest proportion of sawn lumber, about 92½ per cent, is softwood. The most prolific species are: spruce, Douglas–fir, hemlock, white pine, cedar, jack pine and lodgepole pine. All of these are ideally suited either for structural framing or general building and construction work and may therefore be classified as structural woods. These six species make up about 86½ per cent of the total lumber produced in Canada.

At the present time, white pine and cedar are used primarily as decking and siding, spruce, jack pine and lodge-pole pine for general construction work and secondary framing members, while Douglas-fir and hemlock lend themselves best for use as primary structural framing members.

The production of structural wood is ample for present requirements, but the current rate of production is depleting our enormous resources at a fairly rapid rate. The presently readily available stocks of our two most used structural woods—spruce and Douglas-fir—would be exhausted in 56 and 28 years respectively at the current rate of sawmill production, though some of the smaller material will of course have matured by that time and new timber stands not accessible at the moment will have been opened up. Nevertheless, the above figures emphasize the need for careful tree farming and reforestation.

An ever increasing proportion of structural wood is being utilized to its fullest extent in engineered timber structures of various types but, unfortunately, only a small proportion of the total output is readily available for this purpose. While exact figures have never been compiled, it is estimated that only a small proportion of Eastern species, such as spruce, jack pine, lodgepole pine and hemlock, is graded structurally to the National C.S.A. Specifications. Most producers of Eastern species are not even familiar with the National grading specifications and use numerous local rules which are confusing to the uninitiated. This state of affairs greatly limits the structural use of Eastern species due to the uncertainty of a steady supply of satisfactory material. It is to be hoped that some degree of standardization will be reached in the not too distant future and a great deal of effort is being made in that direction by various interested parties.

As far as Douglas-fir is concerned, the situation is somewhat better as 4 per cent or about 70 million board feet annually have been graded structurally for the past few years. This fact, together with superior strength, resistance to decay, size and length of available timber and various other considerations, explains why Douglas-fir is being used almost exclusively in engineered structural members. The supply of graded Douglas-fir is sufficient to meet present demands but grading will have to be stepped up substantially within the next few years in order not to retard the progress of the expanding timber fabricating industry in Canada.

A milestone in the evolution of timber structures was reached when large scale commercial production of glulam was made possible by the development of satisfactory adhesives. With one stroke the limitations of size and length were eliminated and members of any required dimensions could be fabricated. At the same time, the problem of availability of consistently high grade timber had been overcome. In glulam members, high strength lumber is only required in the regions of high stress, for example, at or near the outside faces of a beam, while near the center lower grade material may be used without appreciably affecting the over-all strength of the member. Furthermore, glulam members can be produced in practically any required shape,

opening up entirely new and ever widening fields of application such as glulam arch construction, which combines grace and beauty with efficient structural shape.

The commercial advent of glulam construction greatly increased the need for skilled timber fabricators. Although it is possible to fabricate glulam members, particularly straight forward ones such as beams and columns, in the field, it is an uneconomical and risky procedure. Uniformly high quality glulam members can only be produced under well controlled plant conditions and under careful inspection at all stages of manufacture. Although grading rules for lumber used in laminating have been established in Canada, these have not yet been adopted by most mills. At present, it is therefore necessary for the fabricator to grade laminating stock as the first step in manufacture.

A number of specialized framing systems have been developed. Plywood beams, the H.B. system, the D.S.B. system, and Trofdek fall into this category, but the scope of this paper does not permit a detailed discussion. They all have a very useful field of application and are intended to effect the maximum amount of economy within that field by utilizing the numerous advantages of timber to their fullest extent, by using more plentiful and cheaper lower grade material whenever possible, and by taking full advantage of the reduction in cost inherent in shop pre-fabrication.

In order to continue expansion, the following requirements must be met:

1. The fabricating industry must be able to rely on a continuous and steadily increasing supply of suitably graded timber to put it in the same position as fabricators of other structural materials.

2. A great deal of additional research into the physical properties and behavior of timber must be undertaken and the training of timber engineers must be intensified.

3. Timber fabricators must continue to employ rigid quality control to ensure a uniformly high standard for their products. They must also continue their search for new and improved production methods.

4. The activities of the individual fabricators must be co-ordinated and products standardized as far as possible for the benefit of the purchaser.

5. The promotion of uniform and reasonable design codes, which give due consideration to the special properties of timber, must be encouraged.

6. Greater publicity is essential to inform the public in general, and architects, engineers and builders in particular, of what structural timber has to offer.

These aims can only be realized by close co-operation within the fabricating industry. The formation of the Canadian Institute of Timber Construction has shown that the majority of Canadian fabricators are aware of this fact. Although the Institute has only been in existence for a short time, it has already done a tremendous amount of useful work and will no doubt continue to do so with ever increasing vigor.

Problems of Economy of Timber as a Structural Material

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To deal with the problems of economy of timber as a structural material, it is desirable to look first at the more general field, the economics of structural engineering.

Economics is the science which deals with the production, distribution, and consumption of wealth. Structural materials represent a sizeable fraction of the wealth of the world and certainly of Canada.

The annual value of construction work in Canada represents more than one sixth of the value of the gross national product and in 1954 reached nearly $5 billion. Residential construction accounts for nearly 28 per cent of all construction.

Currently Canada produces less than half the structural steel consumed, practically all the portland cement used, and more than twice the lumber used by the construction industry in this country. Lumber is still the leading construction material, slightly more than half the total, but this represents a decline from 61.2 per cent in 1946. The totals include sheating, siding, and trim, as well as structural timber.

Many markets in the construction field have been lost by the wood suppliers. We are interested in why they were lost, whether they can be regained, and new markets that can be developed for structural timber.

From the structural engineer's point of view, the problems of economy of timber as a structural material can best be discussed by considering the question: "why and when should a designer select timber as the structural material?".

The answer to the question is "when and if the structural designer considers that it would be more suitable than (or as suitable as) any other material which he might select for the particular members or structure".

Factors which would affect the decision are: availability and delivery time, appearance and customer preference, fire hazard and cost of insurance, cost and life of structure.

Availability

In many instances during the 1940's structural timber was used in Canada because it was available while structural steel and concrete were not. This is a situation which might recur. Potentially, our supply situation in Canada for structural timber is better than for either cement or structural steel. Also, in times of emergency, structures can be obtained with timber in less time than with other materials. However, under such circumstances it is almost inevitable that the quality of the material is not maintained at the desired standard.

It is natural for owners and/or designers who have experienced trouble as a result of poor grade structural timber to avoid using it, if and when other materials are available. There has been trouble resulting from poor grade and faulty concrete and steel but it hasn't made as lasting an impression on the minds of structural designers as has the trouble with timber structures. Perhaps there hasn't been as much trouble with concrete and steel, or perhaps the public relations activities of the structural timber industry could be improved.

It must be realized that under emergency conditions low grade stuff will be used because the better grade material is not available or is scarce or is too costly. However, if structural timber is to maintain its position in the competitive market, not only must the quality be good and dependable but the buyers and designers must be convinced that this is so.

Deciding Factors

In many cases, from the appearance standpoint, timber is a natural and has no serious competition. Exposed arches in churches and assembly halls are examples. In other cases, the opinion of the buyer and/or of the designer is influenced by claims of the advocates of the various competing materials.

Timber will burn and this is considered by many people to be a serious defect in a structural material. There are treatments which reduce the inflammability of timber and there are precautions which can be taken in design

which will greatly reduce the fire hazard. Wood retains its load-bearing capacity, its original form, and other physical properties when subjected to intense heat much better than any other commonly used structural material.

The cost of insurance on a building is established primarily by the contents and the fire protection equipment rather than by the fire rating of the structure.

Many items must be considered in determining a fair figure for the cost of a building. These are: initial cost, construction time, useful life, and cost of maintenance.

A comparison of initial cost of structural units (exclusive of erection costs) shows that: for the floor joist and purlin the timber member costs much less than the steel alternative. However, in the case of the 40-foot span, heavily loaded beam the steel member is cheaper.

Whether or not timber will be chosen for structural members on any specific project will depend primarily upon its availability and its cost. Other significant influences will be the personal preferences and prejudices and the considered judgment of the purchaser and the designer.

Discussion

Paul H. Graham (Clinic of Wood): How efficient are nails for providing clamping pressure in fabricating glulam members and what is the proper approach in using them?

Mr. Eldridge: Not too efficient. Most adhesives require a clamping pressure of 100 p.s.i. and upwards, and such a pressure would be rarely obtainable using nails only. Pressure is the important thing in fabricating glulam members. As an example, in a Canadian specification, working stresses are only 60 per cent of the allowable stress, if clamping pressure is provided by nails.

A. F. Lampole (Canadian Public Booth Co.): For the most effective bond, what should be the moisture content of the stock prior to gluing?

Mr. Kennedy: No particular figure can be set for the moisture content of the stock before gluing, because ideally it should be the same as the equilibrium moisture condition of the atmosphere where the glulam member is to be used. However, there are also limitations specified for particular glues and in many cases the two figures are not compatible. A range of 7 to 16 per cent is allowed in the C.S.A. Specification for Glued Laminated Timber Construction 0122–1953.

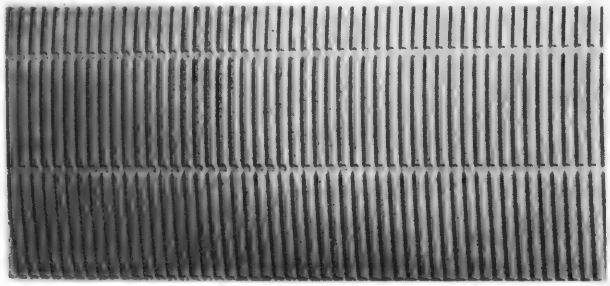
Frank T. Parrish (Heywood–Wakefield Co.): In our area we have trouble with contractors handling the glulam members—unloading them in snow, mud, etc., and sometimes spoiling their appearance. Do you have any problems like that?

Mr. DeGrace: Yes, I have seen that happen. The ultimate answer seems to be educating the contractors to be more careful in handling the members.

Resilient Gluing Rolls

ROBERT S. BLACK
President, Black Brothers Co., Mendota, Ill.

RESILIENT GLUING ROLLS are used in order to conform to stock irregularities and to provide better control over the amount of glue deposited. Both natural and synthetic rubber are suitable, but synthetic is usually best because of its high resistance to the absorption of solvents. The resilient surface is helically grooved to control the amount of glue deposited. By varying the grooving, any range of coating required may be obtained.



Grooving enlarged with 9 helical grooves to the inch and lengthwise grooves spaced approximately 1 inch apart.

Many manufacturers of door and plastic faced panels throughout the country are using a composite grooving to good advantage on their glue spreader rolls. Instead of the conventional helical type grooving used for plywood and panel laminating, a special composite grooving consisting of both helical and lengthwise grooves is used which applies an even and economical glue line to one or two sides of the door frame assembly. The grooving is especially advantageous when using polyvinyl adhesives.

This grooving saves adhesive as well as making a cleaner operation, as it tends to eliminate the "wring-off" on the sides and trailing edge of the frame as it passes between the gluing rolls.

Research Facilities and Program of the Western Pine Association[1]

CARL A. RASMUSSEN

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The research program and facilities of the Western Pine Association have been designed for use of members manufacturing lumber and customers using this lumber. Completed research projects are described to illustrate the scope of the Association's program.

THE RESEARCH DEPARTMENT of the Western Pine Association was organized 32 years ago to carry on research and consultation on seasoning. In the first year of operation, the need for other answers was recognized and the research program was expanded. This need has been on the increase over the years and the Association members have built a sound research and development unit now employing 12 persons. Almost all phases of forest products research are studied.

The problems and projects that have been on the program over the years will indicate some of the answers that have been found and the range of ones that might be studied in the future. These fall generally into three classes: (1) projects that assist the users toward increased serviceability or reduced costs, (2) those that assist members in reducing their manufacturing costs or producing a higher quality product, and (3) greater utilization of the tree.

One of the early projects for the users was that of evaluating preservatives for use in the sash and door industry. As standards were developed, it was found that none of proprietary products then available would give the protection desired. This led to the search for a clear, paintable, stable preservative that would not raise the moisture content of the finished product and one that could be applied by simple non-pressure methods. In turn, this led to the development of the commercial use of the chlorinated phenols (pentachlorophenol) first used by the millwork industry in 1936 and now used for a wide variety of treated products.

The next problem encountered for this group was to develop water-repellent standards. The swell-o-graph which was developed is now used for the rapid evaluation of solutions and their effectiveness in preventing water absorption and subsequent swelling.

The sizes of projects vary greatly. The smallest was one with match sticks. The customer, a manufacturer of matches, thought the trouble he was having with breakage might be caused by an early stage of decay in the match block material. Examination revealed no decay but mechanical tests indicated that weakness was caused by cross grain and that greater care was needed in splintering parallel to the grain.

The users of pine economy siding (tight knotted grade) experienced a bleeding of color through the paint coating over the knot area. This problem led to the development of the clear knot sealer W. P. 578. Since its original formulation some 10 years ago, its use has been expanded by pigmenting it and using it for a prime coat instead of just spotting the knots.

The most frequent assistance given users is in the field of finishing. Problems of paint durability are most frequent but those of a good exterior clear finish and the non-darkening of wood are a close second and are being studied extensively. A current project in this field is that of improving the paintability of finger-jointed material.

Another phase of the work of the staff is directed toward manufacturing problems. Three staff members devote most of their time to seasoning consultation in the field. Besides giving assistance on air and kiln drying problems, they train men in the art and develop new techniques in our two test kilns of full size in cross-section, equipped with scale for weighing the lumber as it dries. New methods are continually being investigated in search of a better or faster means of seasoning.

Studies to learn of losses in footage or grade are continually being made to increase the yield in manufacture. Some already completed are related to planer operation, band saw tooth characteristics, and optimum moisture content. One now being studied is the value of blanking lumber before surfacing.

Quality control systems are being set up for use in the sawmill, dry kilns, and planers. Such systems put into effect will enable the plant to learn their present manufacturing capabilities and to keep a record of their manufacture as well as a means of determining when the process is varying beyond predetermined limits.

The prevention of blue and brown stain has and is receiving considerable study. Techniques with the use of anti-stain treatments have been studied for both lumber and logs. Changes in operating procedure have brought

This two-story addition to the Western Pine Association's research laboratory was recently completed. Increasing space 60 per cent, the new structure affords room for the increasing volume of wood research and product development being conducted by the laboratory's technical staff.

[1] Presented at meeting of FPRS Inland Empire Section, August 4–5, 1955, in Butte, Mont.

The Author: Carl A. Rasmussen has been on the Western Pine Association staff for 21 years. He is a past chairman of the FPRS Pacific Northwest Section

about extensive studies of the storage of logs.

The third phase of the program is that of greater utilization. It is rather difficult to define, to some it may mean use of the sawdust and shavings, to others use of the small pieces, and to others greater realization or higher end use of the board. We classify them all under the heading of utilization.

The staff is always searching for commercially available processes for the utilization of sawmill residues. The big problem is to find sizeable outlets for this material without getting the "tail wagging the dog." Information on processes available may be obtained from the association laboratory. Extraction of these residues has been studied in the pines, cedar, and larch with some profitable success. The physical characteristics of western species are being studied for uses in new markets. The use of the western pines for heavy duty flooring is one example. The glue laminating possibilities have been studied for some species and found to be useable.

A product of densified wood from one of the associated species is an example of the development of a process to modify the wood to fit new markets.

Greater realization is obtained through defect removal, edge or end jointing, patching, and various gluing techniques. The development of wide sheathing from low-grade lumber has been studied for increased markets.

The foregoing gives a brief description of how the Research Laboratory of the Western Pine Association can assist members manufacturing wood products or customers using those products.

Problems in Training Wood Technologists[1]

ERIC A. ANDERSON

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Problems in training personnel for the wood industry begin with the freshman entering college, extend throughout his college years, and continue after he has earned his degree. The author explains how some of these problems are met at the New York forestry college. Industry cooperation in proper placement is needed if graduates are to expand to their ultimate limits.

THE FOREST PRODUCTS INDUSTRIES have developed a long way in the last 20 years. Technical requirements in manufacture and in research have reached the point where highly trained people at the professional level are required. An important opportunity for such training is to be found at the forestry schools, many of which have organized departments to provide this training. There is full recognition at these schools that a professional man must have a background of scientific knowledge, plus experience, insight, and judgment if he is to be successful in meeting the requirements of his profession.

How do the schools proceed in this objective of training such men? This is a complex question with a complex, dynamic, ever-changing answer. In arriving at the answer, we must begin with one of the fundamentals of all productive capacities — the raw material from which the product is eventually made. In this case, it is the students. Those admitted must be of high caliber if we are to turn out a good product. Second, there is the teaching staff. These are the grinding wheels, the tempering devices, the dry kilns that take some of the all-too-evident moisture from behind the entering freshman's ears! Third are the facilities for teaching—the building, equipment, fiscal, and maintenance staffs. Finally, there is the employer, on whom the schools rely to provide actual experience to the students.

The problems begin with the potential student. Has he received the particular training in his high school course work that he should have if he is to make the most of his college career? Requisites for successful work in the modern scientific and professional fields are of such a complex nature that time must be used to its best possible advantage during the training period. If the potential student is short on such things as mathematics, English, chemistry, and physics, he must fill the voids when he comes to college before he can go on to more advanced work. In the mass production technique of the so-called "common freshman year" for all incoming students, this is done in mathematics by requiring all students to take certain courses which might have been taken in high school. Loopholes for the students with a more advanced background are provided by allowing —and sometimes requiring—him to take examinations which, if passed, permit him to go on immediately to more advanced work.

In the field of forest products there is another special problem. Most of the schools where specialized curricula are offered in wood technology, forest utilization, forest products, pulp and paper, and the like are forestry schools. Personnel directors recruiting college seniors for jobs after graduation are often surprised at the breadth of these programs.

One crucial problem to be solved is that the opportunities at forestry schools must be brought to the attention of high school students whose aptitudes and interests fit them for this particular field. If the high school counselors can be made aware of the opportunities available at forestry schools, perhaps these counselors can reach the students. They may be able to get many students who, without knowing it, are interested in our specialized training, to at least open the forestry college bulletin of courses and look over the programs of study. Many of the boys may be delighted by what they find available to them at a school they had thought trained men only to grow trees and nothing of how to use the trees.

There now are some means for accomplishing this. In New York State, at least, many high schools have so-called "career days." To these come representatives of the institutions of higher learning to consult with prospective students. Many schools, forestry schools included, provide brochures which are brief outlines of the specializations offered at their particular institutions. We hope, of course, that alumni will help spread the word in their ordinary day-to-day conversations when friends come to them for advice on schools.

[1] Presented at meeting of FPRS Northeast Section, Nov. 5-6, 1953, in New Haven, Conn.

The Author: Eric A. Anderson holds B.S.F. from U. of Washington, Ph.D. degree from State University of New York College of Forestry. He served 13 years with the U. S. Forest Service, at the Forest Products Laboratory and Southern Forest Experiment Station. He joined the Syracuse college faculty as professor of wood technology in 1950, was appointed department chairman in April 1952.

The curricula must go further than merely offering courses in the various subjects of a specialization. We now have on our faculties men who are interested in production phases as well as those who think in terms of research and teaching. Measured in numbers, the greater demand for graduates is, and will continue to be, for production-trained men (including the merchandising and construction fields). These are the broad base of the flying wedge. At its apex are the fundamentalists—the researchers and teachers. All are interrelated and training in fundamentals does not exclude a man from production or vice versa. There are too many and varied problems in both fields to allow such exclusion. Nevertheless, the formal academic training must be different for these two kinds of trained men. There simply isn't time in four years to provide a man with the tools to take his place in production at the same time that he receives the advanced knowledge of chemistry, physics, and mathematics that he must have for research in the fundamentals of wood and wood use.

Balance Needed

In curriculum planning, there are serious problems. Curricula change constantly under the pressure of new ideas in education, increased knowledge of wood and manufacturing processes as they develop through research, and even of social pressures. Taken by themselves, changes required by increased knowledge are relatively easy to make. Courses are subdivided and become more specialized, all of this leading to further specialization by the student. Obviously, there must be a balance in specialization so that the interests of the student are protected.

New ideas in education are harder to integrate with the program. Such ideas can only be evaluated by trial and it ordinarily takes many more than the four academic years to see how good the new idea really is. Even after long periods of time—decades—an attempt at true evaluation of an idea may result only in argument. One always has to remind oneself that adding material through the door of the classroom pushes other material out the window.

Social movements are another factor to be considered. Most will agree that there have been great stresses exerted in our American society and in world society during recent decades. These stresses have developed an awareness in all of us that we must have our eyes open politically, economically, and socially to horizons that go far beyond television range. How do these stresses show up in a forestry school? By endless discussions of the relative merits of liberal education versus training in the basic sciences. By constant consideration of the value of a course in civics, English or psychology as opposed to another in chemistry.

Should we turn out a man who is fully equipped in the ability to take his place in the structure of his community but is weak in the knowledge of the sciences and production methods that he ought to have? Or should we turn out a man who has a sound knowledge of the sciences and production methods and only a little training (insofar as he gets it in formal courses) in civic responsibility? Or can we hit a happy medium? The problem is a tough one. Do you want a man in your production organization who knows little of production, or a man in your research organization who has little fundamental knowledge of the materials you work with? It's easy to say that the man should be balanced but with the vast amount of knowledge now available and with specialization so great, schools have troubles in giving graduates the ability to understand economic movements in the world and energy movements in the atom!

In my opinion, the wood technologist aiming at research should get a sound training in the related sciences and in wood, with as much additional formal, liberal education as can be packed in. The wood technologist aiming at production must loosen up a bit in the fundamental sciences to allow production courses their place, with the liberal education again packed in.

In saying this, I may be criticized for not saying that we must turn out a complete and polished university graduate who can talk labor relations with Mr. Reuther, foreign affairs with Secretary Dulles, smoke cigars with Mr. Churchill, and write like Gilbert Highet. There is a simple reason for my belief. I believe that we only start our men along their way when we hand them a diploma. What we can do is line them up on a path that leads out into the future, give them a compass of principles, a gentle push, and turn them loose. To expect the average college graduate with the terrific amount of information he must absorb in four years to be as facile in the use of that information as the man who is ten years out of school is too much. A man worth his salt goes on learning every day of his life. He absorbs knowledge and skill by seeing, hearing, doing, and studying. When he stops this process, he becomes a mere machine capable of so many revolutions per minute and no more. Our job is not only to give him facts but to cultivate a desire for knowledge—a desire that will last him a lifetime.

School's Responsibility

To the student, the school has a responsibility for providing a course of training suited to the requirements of the profession and to the individual student's peculiar talents. This is another way of saying that there must be an analysis made of the student's special abilities, a correlation of the curriculum content to develop these abilities and at the same time fulfill the objective of bringing him up to the professional level he should have reached by the time he receives his degree.

If this responsibility to the student is to be satisfied, the curriculum must be reasonably flexible. Such flexibility can be obtained by inserting a number of elective hours of credit so that the student may to a degree control his specialization. Certainly he must be counseled in his choices by people who understand him and his needs. One method of meeting this need for flexibility in the curriculum is the procedure now used by the Department of Wood Technology at the State University of New York College of Forestry.

All boys matriculating at this college take the same courses during their freshman year, whether they expect to major in wood tech, general forestry, or whatever. An exception is made to take care of those who have had sufficient work in certain subjects before matriculating. For example, a boy who has had trigonometry in high school takes an examination in this subject prior to the beginning of his freshman year. If he passes the examination, he is permitted to go on with more advanced mathematics.

Among the required coures in the first semester is one in general forestry designed, among other things, to give him a broad understanding of the various fields encompassed in the profession of forestry. He is permitted at the beginning of his sophomore year to make his choice of these fields. He consults with selected representatives of the faculty and anyone else whom he cares to buttonhole. The alumni help supply counseling assistance by providing advisors who consult personally with the boys.

Those boys who select wood technology as their major field of interest then decide whether they wish to emphasize wood chemistry, wood anatomy, or physics and mechanics of wood (the latter might be termed wood materials engineering). During the sophomore year, such a choice specifically affects only one course.

However, they have an additional elective course which it is hoped they will use for broadening their education by taking work in economics, sociology, or the like. In the junior and senior years, they specialize further in their chosen fields at the same time taking a number of electives of their own choice. The criterion for these electives is that they broaden the student's professional competence.

Industry Cooperation Urged

Another problem is placement of graduates in the right positions where their particular talents and interests will allow them to expand to their ultimate limits. For this we need the cooperation of all potential employers, beginning with the undergraduate and his free summer periods and continuing with the graduate himself. Experience is one of the best ways for a boy to find out if he is suited mentally, temperamentally, and physically for the specialization of his choice. Once he rubs the gilt off his own personal, glamorized version of his field of interest, he can determine for himself whether the foundation substance is pure platinum or—for him—just clay. He should start this rubbing process in a very practical way in his vacation periods by working at a job that is as closely related as possible to what he thinks he finally wants to end up doing after graduation.

To help him at this point, we must be able to place him in a temporary job with an employer who will be sympathetic to his needs for breadth of training and who will help him with a little advice when the need arises. Naturally, executives are busy men with limited time. But it is well to remember that the college-trained man is potentially an executive or a skilled technical and research worker who will fit into someone's organization. It is good business for industry to get a preview of its potential future personnel. That way, by a little judicious screening and limited expenditure of dollars and hours, a company can net men who are most suitable to its organization and who meet its own standards.

As commencement approaches and the need for finding a permanent position faces the graduate, he will naturally lean toward the company where he already has a record of satisfactory employment — especially if he was treated with understanding by the management.

It is clear that training good wood technologists is no simple matter. The problems begin with the entering freshman, extend throughout his college years, and continue on into his professional career after he has earned his diploma.

Stowing and Bracing Lumber for Shipment in Box Cars[1]

LAWRENCE M. RANDLE

Former Representative, Acme Steel Products Division, Acme Steel Co., Spokane, Washington

Analyzes details of the principal problems connected with stowing and bracing lumber for shipment in box cars. Step-by-step process followed to arrive at solution to problems is given. A number of lumber producers in the Inland Empire area are now using this system to minimize damage in transit and reduce materials handling costs.

IN THE LAST FIVE YEARS an awakening has been taking place to the need for improving the arrival condition of cars of lumber, to reduce damage in transit, and to substantially reduce materials handling costs after lumber is shipped from the producing mill. In the past two years, particularly, there has been a steadily growing number of producers who have become convinced of *why* they should be doing something about improvement of their service in this regard, but who are today groping for effective and reasonably low-cost answers to the questions of *how* lumber can be more effectively stowed and braced in box cars.

From the lumber car receiver's viewpoint, improvement in car arrival condition is necessary and is being demanded. Producers of materials competitive to lumber have recently given greater effort toward better packaging, lower materials handling costs, and better car bracing of their products.

It is known that a good percentage of cars of lumber arrive in generally satisfactory condition without any special bracing in them. In our test work, this had to be taken into consideration and each idea given the most extensive experience possible. We had to avoid the pitfall of believing that because 30 or 40 cars using one bracing idea arrived in good condition, the idea must be good.

Furthermore, it was found that we must work almost solely with results of findings at destination. Ideas that looked good after receiving impact tests in a producer's yard or local rail yard frequently looked poor after receiving 2,000 miles of vibration and other transportation treatment.

The ideas contained herein are composite ideas of many contributed by a number of producers. Their thoughtful efforts in contributing to the common pool of experience and knowledge is acknowledged.

Three Traditional Patterns

Basic to this presentation are three traditional stowing patterns, indicated in Figs. 1, 2, and 3.[2] Fig. 1 is the conventional pattern of straight-up, squared off face, tilted load, random lengths toward the car ends. Fig. 2 shows the "cargo-load" pattern for the bottom quarter to one-third of the load, wherein lumber is "doubled-through" from end to end and the upper portion is stowed square at the face. Fig. 3 is the pulled-out step or platform, originally intended only as a means of easing the job of stowing lumber to the visible capacity of the car.

The end result of this work is delivery to the customer of cars of lumber in relatively damage free condition and in such condition as will make possible lowest costs of unloading.

The principal and greatest cause of degrading damage and excessive unloading costs is excessive shifting of lumber. If lumber were loaded and shipped in modern railroad passenger-type cars, and if those cars were transported with the smooth ease of passenger trains perhaps there would be no problem. This is cited only as a comparison to the known conditions of freight lading box cars and of

[1] Presented at meeting of FPRS Inland Empire Section, August 4-5, 1955, in Butte, Mont.
[2] Figures are not working drawings and are intended only to show basic ideas.

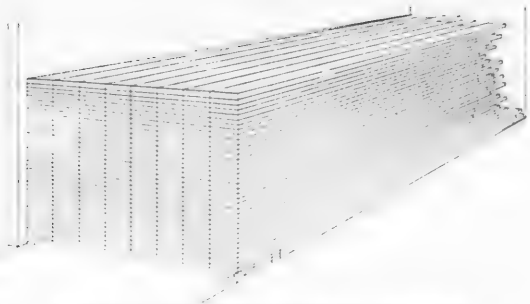

Fig. 1.—Tilted load with random lengths toward ends of car.

Fig. 2.—Cargo-type load.

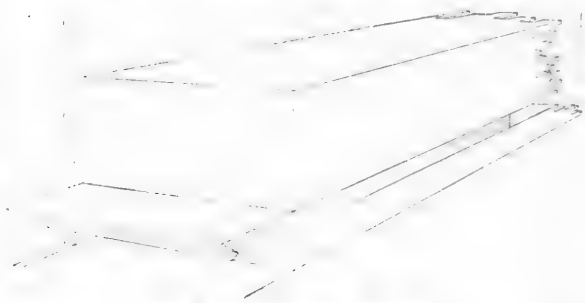

Fig. 3.—Half-car unit with step.

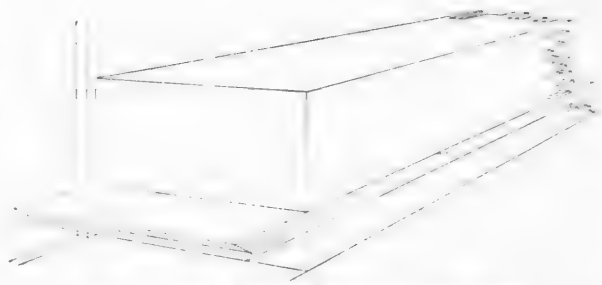

Fig. 3a.—Step or platform loaded in cargo pattern.

fast-moving freight trains, wherein cars and their lading receive heavy shocks and relatively rough treatment.

Not all box cars receive violent impacts and many do not. However, most cars receive a large number of minor impacts. There have been impact recorders in a number of cars which revealed the number of jolts that most cars receive.

Because of these conditions, excessive shifting becomes possible by reason of open areas or voids remaining within the total cube of the car after all lumber is stowed. The voids are located in the mid-car section and in the two end sections. The end section voids are occasioned by the usual condition of random length lumber.

Because it is common experience to have to load 10-, 12-, 14-, and 16-foot lumber in each car end, it has not yet been found practical to stow all lumber is stowed. The voids are Nor has it been found practically possible to unload cars of lumber stowed against end-walls. Some of the large producers have taken steps toward segregation of specie and grade by length, to aid in more efficient stowing patterns. But this is found to be impractical by other mills and is quite expensive.

A practical definition of excessive shift is that amount of shift of either individual pieces or units to move them into void areas beyond the balance point of those pieces or units. An example would be where 12-foot lumber in the upper portion of the car shifted out from over the lower portion by 6 feet. This would be the balance point and such lumber would then slip diagonally down into the lower void.

Fig. 4 shows a typical example of what can happen when a car receives a violent impact. This is just one of many patterns of what happens when lumber shifts excessively.

Other Factors

Important to this research work was the realization that beyond the possibility of violent impacts is the usual condition of the car and its lading heaving up and down hundreds of thousands of times in transit, coupled with the many starting, stopping, slowing-down, and speeding-up jolts. Under these conditions the lumber "walks" or "shudders" toward the voids and the top portions eventually slide off into the pockets, especially if near the end of the trip the car receives rather rough handling.

Shifting in itself is not entirely undesirable. A certain amount of "riding" and the punch of starting and stopping jolts and coupling impacts during switching is desirable in most instances.

Another important factor to be reckoned with in this problem of excessive shifting is the condition of having extremely large numbers of individual pieces in each car end. Taking as an example, an 8-foot 6-inch wide car loaded entirely with 1- x 6-inch lumber, each end would have about 17 boards wide and about 110 boards high, or a total of roughly 1900 pieces in each end. This is a complex situation in relation to possible impact forces working to shift the load within the voids. Compare this with refrigerators, for example, that might be stowed just three units wide across the car and solid from the door area to the car ends.

The problem is now more clearly defined as being one of preventing thousands of pieces from shifting to such an extent as to drop at angles into either fore or aft voids in the car.

Disadvantages of Patterns

Fig. 1 is a good stowing pattern. But trouble for the car unloader develops because with this tilted load,

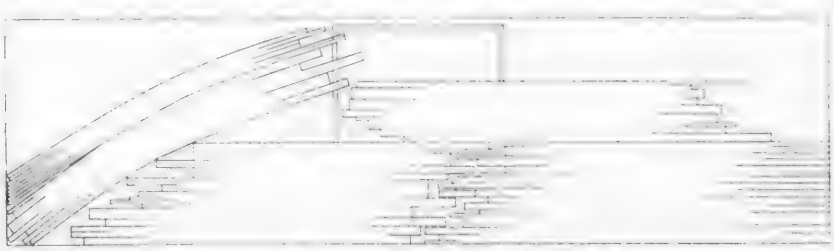

Fig. 4.—Typical effect of excessive shift of lumber in box car.

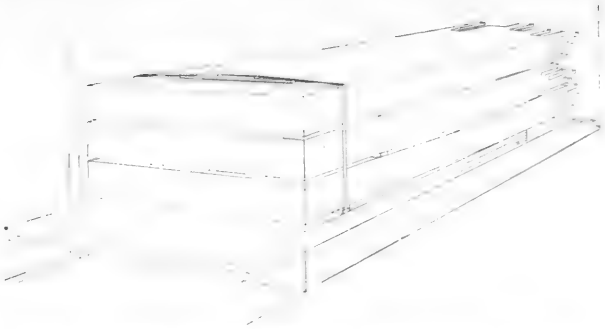

Fig. 5.—Lumber unitized above step with flat steel strapping.

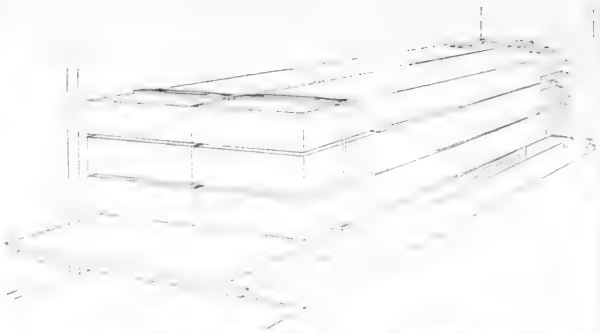

Fig. 6.—Lumber units above step side-by-side strapped separately to increase compression.

random length lumber works down to the car-ends and makes it much more time costly to unload 10- and 12-foot lengths. Under violent impact conditions, the lumber shifts excessively as shown in Fig. 4.

If tariff regulations were to permit less high loads, these problem conditions could more effectively be controlled and this stowing pattern would then become the least expensive, to the shipper, as well as to the receiver. But it is highly unlikely that such regulations will be modified to such an extent.

Fig. 2 is a better stowing pattern. It lessens the total void area within the stowed load. It puts more lumber in a car or puts an equal quantity of lumber into it in such a placement as to make possible easier control of shifting.

But, it also presents two problems:

1. Planning and segregation of lengths are required to effect the "doubled-through" stowing pattern in the lower portion of the car. This is almost prohibitively expensive to most mills at the present time.

2. Receivers of such cars are beginning to become more vocal about their objections to it. They claim to have serious time-cost losses from having to vertically lift so many boards in such lower sections, the boards being tightly wedged into a solid mass.

Fig. 3 has been a good stowing pattern. It has an outstanding weakness in that the pulled-out step platform leaves voids at each car end. When the car is hit during switch coupling, frequently these two voids consolidate into one void at one end and allow the lumber to fall at a cocked angle with one end toward the roof.

Proposed Solution

Fig. 3a is the first proposal of detail in solution of this over-all problem. Here the significant difference is that the pulled-out step section or platform, about a foot thick, is in itself doubled through or cargo-loaded. This relatively small section of doubled-through lumber in effect establishes a "new floor" to the car, greatly minimizes the problem referred to in Fig. 2, and reduces the total "problem area" within the car by one-third.

Having eliminated one-third of the problem area, what can be done with the top two-thirds portion. It was previously stated that a complexity of the problem is occasioned by having an extreme number of individual pieces. The stowing system in Fig. 3a substantially reduces the total number of pieces to shift excessively.

However, there still are a large enough number of pieces to cause serious trouble. So the next step is to convert the large number of individual pieces into a solid mass. And this is done quite naturally with some kind of binder. In this case, the use of flat band strapping of adequate size and surface quality is suggested.

Early in this work it was discovered that there was no size of strapping and/or existing strap tensioning tool that had the capability, in just one strap, of so effectively unitizing a cross-section of lumber 8-foot 6-inches wide and 6 feet high as to prevent excessive shifting. "Coring-out" of individual pieces in the mid-section quickly develops. The unitizing band slacks-off and there is then no bracing. Because lumber is stowed so high in cars, there is no practical possibility of putting more than one band around and over the top of the load. This one band must be placed as far back as a man can reach, about 2 feet.

Cases Vary

It should be specially noted, however, that some real advantages have been found in placing two bands, parallel to each other, around the load. These are sometimes out-weighed by the disadvantages. Each case presents its own problems and it is recommended that these be worked out with the strapping manufacturer's representative.

The principal problem that we were confronted with up to this point in development work was this "coring-out" condition.

Here is a significant point. It was learned that the effect of strap bracing or unitizing of lumber is in direct proportion to the amount of vertical compression equally distributed throughout the load. While we could not substantially increase the amount of vertical compression, we could more equally distribute the vertical compression by installing stickers within the load and by use of three-piece trusses under the band on top of the load. This was a major point of progress.

The coring-out problem was thereby substantially reduced. But continued experience and testing revealed that there was still too much coring-out of pieces to consider this simple strap bracing idea to be practical.

Fig. 5 shows this system of one or two parallel bands, with three piece truss, and stickers within the load. There are a few mills now using this system with what they consider to be reasonably good results. But it has definitely limited value.

Next came the idea of vertically splitting the half-car unit into two side-by-side units, each having separate straps, separate trusses, and separate stickers (See Fig. 6). This idea became another major step in our progress and there now are a number of mills using this system. It is significant to mention that with this system it is found completely practical, and time-cost saving, to install the strapping after all the lumber is stowed.

Related Costs

Beyond the cost of strapping, additional time-costs to strap bracing are occcasioned by having to level off the loads for placement of stickers. Installation of stickers in the load does slow down the loading but they are a necessity to effective strap bracing. This basic fact is known from a large number of years of experience in preparing highway carrier shipments and from experience in bracing lumber on flat cars.

After a very large number of cars were shipped in this manner and checked at destination, two factors became apparent:

1. Even in this 4-foot wide and 6-foot high package or unit with stickers

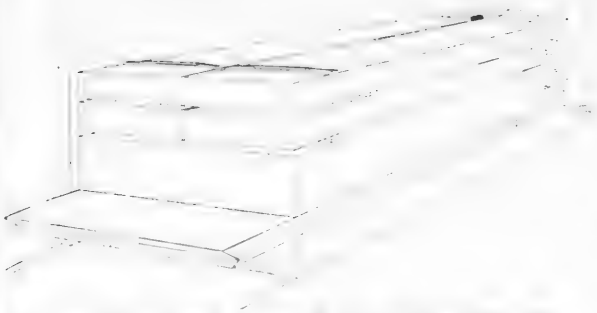

Fig. 7.—Top lumber strapped in two small-size units with stickers and trusses to restrict movement.

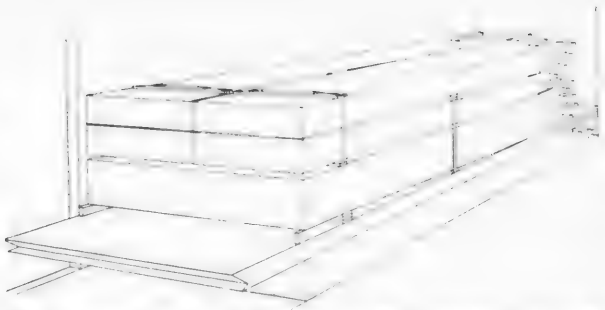

Fig. 8.—Tilted load above step combined with chain-tie principle to prevent shift of lumber into doorway or toward end of car.

and trusses, we were still experiencing too much coring-out;

2. The top 3 to 4 feet of the load area causes most of the problem.

The next step, in a very large number of cars, was to stow the mid-section of the load not braced at all and confine strap bracing to two top side-by-side units roughly 4 feet wide and just 3 feet high or thick (See Fig. 7). And then came development of the stowing idea previously shown in Fig. 3a wherein the "platform" is cargo-loaded, preventing development of large voids in the lower portion of the load.

After considerably more experience, we became convinced that this was the right approach, with smaller units and reduction of void areas. We were consistently able to hold the smaller units together as solid masses. And, of great importance, we learned that it took extraordinarily heavy impacts to move these solid masses far enough to cause tipping into doorway area voids.

A number of mills are using this system now. It is believed to be about the lowest cost system. It is not perfect but it is doing the job of reducing the frequency of important complaints.

Important to shippers and receivers of pattern and tongue and groove lumber is the fact that unit packaging with flat band strapping prevents that vertical, heaving, up-and-down movement of boards that causes the frequent complaints of fractured tongues and grooves.

Another Effective System

At some mills shipping higher grades of lumber, and for shipments into "problem areas," a still more effective system of bracing is desirable.

Up to this point, we have stayed away from the idea of using the "tilted-load" idea, mainly because with that system we could not control effectively enough the shifting or "walking-down" of shorter lengths to the car ends and thereby slacking-off of bracing bands.

Because the basic idea of tilting the load has certain fundamental merit, however, intensive study and testing was carried on wherein this method was combined with methods already described. Out of this test work came the "chain-tie" principle idea (See Fig. 8).

Experience with this system to date has taught that this chain-tie feature causes the entire middle and top portions of the load to shift as a unit, and prevents to a large degree the previously mentioned "walking-down" of individual pieces into the car ends.

This system has been under test for some time and studies are continuing because this composite idea is offsetting about all of the basic negative element components previously stated as the problem:

1. Total void "trouble" area within the cube of the car load is substantially reduced.

2. Pieces are bound together into heavy weight masses that require much greater impact forces to move.

3. While shifting is a possibility, excessive shifting is virtually eliminated.

4. Without excessive shifting, extraordinary unloading costs are eliminated.

5. Without excessive shifting, there is much less probability of degrading damage to lumber.

6. Customers' direct and indirect materials handling costs are substantially reduced; customers are more satisfied, thus stabilizing and improving satisfactory customer relationships.

This direction of thinking and work on bracing of lumber is not the only one that has been pursued with some success. For example, the bracing system utilizing bulkheads, reinforced with flat steel bands anchored into the sidewalls of the cars, has been developed to a high degree of efficiency for use in cars of high grades of lumber.

All of this is typical of the effort of the strapping industry to serve the best interests of the lumber industry. With a continuation of this splendid cooperation, the progress that has been made to date will, in the future, seem small.

Around the World in Forest Products Research and Development

Scanning World-Wide Forest Publications

Results of Counter and Climb Ripsawing Investigations

Torsten Englesson, Gullik Hvamb, and Bertil Thunell. Norwegian Institute of Wood Working and Wood Technology, Blindern, Oslo, Norway.

Reports results of an investigation carried out at the Swedish Forest Products Research Laboratory, Wood Technology Dept., in cooperation with the Norwegian Institute of Wood Working and Wood Technology.

Purpose of the investigation was to compare counter (conventional) and climb (feeding in the same direction as the rotation of the saw) ripsawing methods under conditions which promoted overheating in an attempt to discover reasons the saw blades overheat so rapidly in the climb method.

Results observed were that with climb sawing, the sawdust travels further before it is cleared than with counter sawing. There is therefore more tendency for the sawdust to leave the gullet and cause friction between the saw blade and the specimen, which may be a source of heat generation.

The attack angle—the angle between the feed (fiber) direction and the breast of the tooth—is discussed. For the same hook angle, the attack angle is such that with counter sawing the teeth tend to break and tear the fibres, but with climb sawing the teeth cut and pull the fibres. To secure the same cutting action with climb sawing it is necessary to give the teeth a negative hook angle of about 15°. It was also found in using positive hook angles in climb sawing, sawdust was projected across the gullet space at high velocity and escaped from the gullet, causing heating due to friction. Climb sawing was possible when negative hook angles were employed.

Using a redesigned saw and equipment with negative hook angles, it was found that with climb sawing the power required to cut was from 50 to 70 per cent greater than with counter sawing. The feeding power was about 70 per cent less, but this did not make up for the large increase in sawing power.

Another test was made with a swage saw using positive hook angles. Measurements showed that the cutting accuracy was unsatisfactory with positive hook angles. With negative hook, the accuracy with climb sawing was as good as for normal counter sawing with positive hook.

Australia

● Scarf jointing of veneers—a new method for better utilization. The shortage of peeler logs for plywood necessitates new approaches to economy, evidenced by increasing use of splicing equipment. A new method of effecting savings has been reported in Europe recently, end-scarfing of veneers. This make possible the use of materials from short bolts, round up off-cuts and faulty peeled veneers. Further particulars on the current practise of this process may be obtained through the Chief, Div. of Forest Products, C.S.I.R.O., 69–77 Yarra Bank Road, South Melbourne, Australia.

● Any large research organization such as the Div. of Forest Products, Australia, requires highly specialized, costly, and often unique equipment. The Craig machine is one such item.

Lignin is an important constituent of wood, removed chemically in pulping. In the investigation of possible uses for lignin it is necessary to separate it from other chemically similar substances with which it is normally mixed. The method is based on the differing solubilities of these substances in different liquids, and involves shaking and decanting. The automatic Craig machine, not available commercially, was designed to perform this process. It cantains 50 transfer tubes, drive unit, and electronic control. A separation which might take months if conducted manually can be carried out in a matter of days. The machine is adaptable to other uses than for lignin.

Brazil

● A bill has been introduced in the Brazilian Chamber to reduce exports of Paranà Pine by 20% each year until 1960, when they will cease. The object is to limit production to the requirements of the home market since these forests would otherwise, according to an FAO report, be exhausted within 40 years. Further legislation will be introduced to stimulate replanting of cut-over pine forest.

—Forestry Abstracts

Canada

● The Terry Machinery Co. Ltd., Montreal, has designed a working model of a pipeline for transporting wood. Using Terry pumps and a venturi, they have moved pulpwood bolts through the pipeline at a rate of 16 m.p.h., and reckon they can deliver 30 cords/hour at 128 bolts/cord, over any distance. The cost of installing such a pipeline would be high—$35,000/mile for 20-in. steel pipe and about the same amount for installation, for a maximum bolt diameter of 12 in. —which would limit the system to very short distances and very large volumes of wood.

—Forestry Abstracts

● Investigations are in progress at the Ottawa Laboratory on the possible use of high-temperature drying for Canadian timbers. Recent tests in a special kiln have shown that the range of final m.c can be brought within acceptable limits, if a sufficiently high rate of air circulation (500 ft./min. and upwards) is used, together with a periodical reversal of its direction. Canadian softwoods react well to drying at temperatures above 212° F., and there is little degrade. Drying times are only 1/5th of those in conventional kilns.

—Forestry Abstracts

Great Britain

● The Ministry of Transport and Civil Aviation has approved the use in British passenger vessels of the Danish laminated board 'Novopan' for making structural, insulating, and fire-retardant partitions and divisions. The material is already used extensively in ships built in many other countries. 'Novopan' B is a laminated board consisting of a core of synthetic resin bonded wood fibers and layers of asbestos, faced on each side with two cross-banded hardwood panels.

—Forestry Abstracts

U.S.S.R.

● The Institute of Forest Technology, Lwow (Russian Poland), has experimented with cutting tools vibrating electromagnetically in the direction of the cut. It is claimed that cutting results were good, that no sawdust was produced, and that the cutting surfaces were smooth as if planed.

—Forestry Abstracts

Abstracts From Current World Literature

Construction

Timber construction standards. American Institute of Timber Construction, Washington. 1954.

Contains the following standards and classification recommended by the American Institute of Timber Construction: (1) construction and service classification; (2) specifications for the design of structural timber framing; (3) minimum standards for the fabrication of structural timber; (4) minimum standards for erection of fabricated timber; (5) outline specifications for structural timber framing; (6) code of standard practice; (7) reference specifications and codes; and (8) notations and abbreviations. [For. Abs. V. 16, No. 4]

J. G. Sunley. The strength of timber struts. Forest Products Research Special Report No. 9, 1955.

This paper gives details of the results of tests made on timber struts of the type used in light constructional work. The application of various theoretical formulae to a material such as timber is discussed, and the work of other investigators in the same field is considered. The results of tests made on good quality timber are lower than the theoretical values for perfect materials and conditions, but imperfections in the material can be represented by formulae in various ways.

Factors affecting the load-carrying capacity of timber struts vary; long struts which have a ratio of length to cross-sectional dimension of 25 to 1 or greater fail by buckling, and short struts where the ratio is less than about 10 to 1 fail by crushing; those of intermediate lengths fail by a combination of both.

The conclusion drawn from the tests is that the Perry formula is the most suitable for the representation of the strength of timber struts because it is easily adaptable to take into account the reduction in strength caused by defects such as knots, as well as representing the strength of clear timber struts reasonably. [F. D. C. Tech. Bul. V. 5, No. 28]

Waste Utilization

Wissing, Arne. The utilization of bark. II. Investigation of the Stiasny reaction for the precipitation of polyphenols in spruce bark extractives. *Svensk Papperstidn.* 58, no. 20: 745–50 (Oct. 31, 1955). [In English]

In connection with an investigation on the utilization of the extractives of waste bark of *Picea excelsa*, the author studied the suitability of the Stiasny formaldehyde-hydrochloric acid test (I) for the analysis of that fraction of the extractives which is capable of forming resins through reaction with formaldehyde. In tanning chemistry, this test is always run with a tanning solution of analysis strength (a concentration of 4 g./liter of tannin, determined according to the hide-power method). In the present work, extracts of such extremely varying concentrations are obtained that it was of great interest to determine the influence of the concentration of the extract upon the result of the test. Data are presented which show that, for the quantitative determination of the fractions of tanning extracts forming reaction products with formaldehyde, (I) gives comparable results only at the same concentration of tanning material and within a narrow range of pH. The influence of insoluble matter of the tanning extract is also discussed briefly. [Bul. Pap. Chem. V. 26, No. 4]

Uses of small wood and sawmill waste. *Skogen* 42 (7), 1955 (121–5). [Sw.]

Short papers read at the annual meeting of the Svenska Skvogsvardsförening, with discussion: Available amounts of small wood and sawmill waste (*B. Thunell*); The use of small wood and sawmill waste in the pulp industry (*N. Arve*); The use of small wood and sawmill waste in the fibreboard industry (*B. Segring*); and Experience in burning chips (*F. Berg*). [For. Abs. V. 16, No. 4]

Technical Fair, Hanover, 1955. Apr. 24 to May 3. *Holz Roh- u. Werkstoff* 13 (4), 1955 (121–60). [G.]

This issue contains the following articles dealing with some of the machines exhibited: (1) Preparation of wood and wood waste by comminution and blast-screening (*W. Beushausen*); Tendencies in the development of wood-planing machines (*F. Haase*); (3) Development of cylindrical grinding machines in Germany and the U.S.A. (*Z. Hultkvist*); (4) Discontinuous and continuous methods and plants for the manufacture of wood chipboards (*K. Steiner*), and (5) Considerations on the industrial barking of wood (*R. Bott*). [For. Abs. V. 16, No. 4]

Chemical Utilization

Ross, J. D. [Compiler]. Bibliography of wood distillation, 1907–1953. Oregon Forest Products Laboratory, Corvallis. 1955. pp. 55.

Covers world-wide published work in the divisions: (1) books, listed alphabetically by author's name; (2) articles and bulletins, listed chronologically and by author's name under each year; (3) patents, listed chronologically under each country and by author's name under each year. *Chemical Abstracts* references are included where possible. [For. Abs. V. 16, No. 4]

Particle Board

Cliquet, G. Treatment of wood wastes. Fr. Patent 988,996, Sept. 3, 1951.

In the manufacture of composite bodies, e.g. structural elements, from wood chips or saw dust, the chips or sawdust are treated by stirring with an aqueous medium containing cultures of fungi, e.g. *Phellinus dryadeus* or *P. megalloporus*, to destroy the incrusting substances and free the cellulose fibers. The fibers are then preferably heat-pressed at 80–120° and 8–30 kg./sq. cm. pressure for 15 minutes. Part of the aqueous solution is used to inoculate the succeeding treating solutions. [Chem. Abs. V. 50, No. 8]

Liiri, O. Specifications and testing methods for fibre boards in different countries. *Pap. ja Puu* 37 (4), 1955 (175–88). [Fi.e.]

Standards of U.S.A., European countries, and FAO, are tabulated. [For. Abs. V. 16, No. 4]

Wood Preservation

Voss, W., and Scholz, E. Impregnation of wood. *German Patent (East Germany)* No. 1978, Nov. 26, 1953. [G.] From *abstr.* in *Chem. Zbl.* 125 (30), 1954 (6860). [G.]

Wood is impregnated with sulphite waste liquor or with aqueous solutions of lignin substances isolated from sulphite liquor or with products of their transformation, together with formaldehyde and substances such as phenol; these can give condensation products with the lignin contained in the liquor, and with other substances, such as amines, amides of acids, or phenols, which give condensation products with formaldehyde. [For. Abs. V. 16, No. 4]

Poles

Csuhay, I. Statics and moment of inertia of twin wood poles. *Elektrotechnika, Budapest* 47 (12), 1954 (355–9). [Hu.] From *abstr. in Elect. Engng. Abstr.* 58 (688), 1955 (No. 1531).

A revision of the (Hungarian) draft standard specifications for overhead power lines is suggested. In support of this, a critical analysis is made of conventional methods of calculating the stresses and moments of inertia of twin wood poles. A comparison of costs is made for single and twin wood poles, much in favour of the latter. [For. Abs. V. 1, No. 4]

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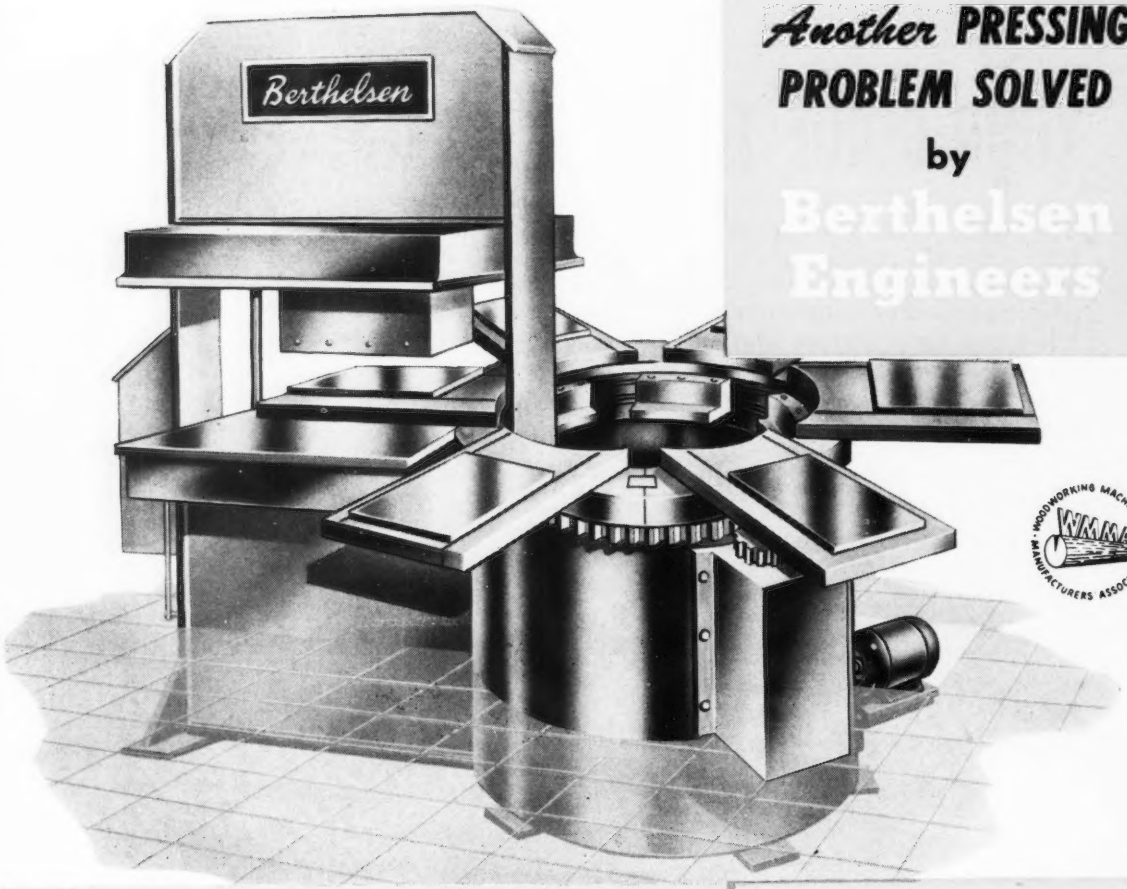

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